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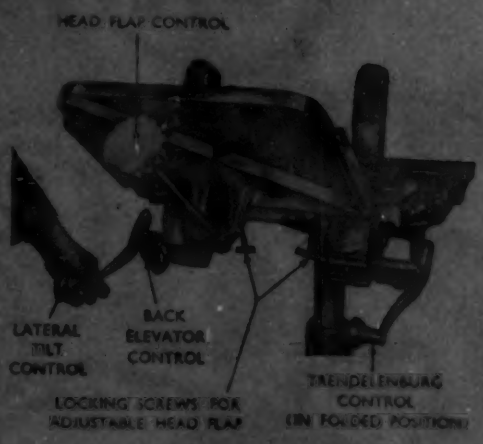
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THE
BRITISH JOURNAL OF SURGERY

VOL. XLII MAY, 1955 No. 176

INJURIES OF THE TRIGEMINAL NERVE, ITS GANGLION AND ITS DIVISIONS

BY GEOFFREY JEFFERSON AND JOSEPH SCHORSTEIN

FROM THE UNIVERSITY DEPARTMENT OF NEUROSURGERY, MANCHESTER ROYAL INFIRMARY AND THE WEST OF SCOTLAND NEUROSURGICAL UNIT, KILLEARN

IT is significant of the rarity of trigeminal injuries that so few clinical studies have been made of these interesting lesions and no collections of major importance assembled except those of Wilbrand and Saenger (1901) and by Bonnet (1904) in a Bordeaux thesis. Trigeminal injuries are scarcely mentioned in even the largest text-books of surgery. A good account of the available handful of cases was written by Prescott Hewett in Timothy Holmes's admirable *System of Surgery* (2nd ed., 1870), but since these dates they have been dismissed in a few words. H. E. Mock (1950) remarks that he has seen 3 cases of trigeminal injury in 3176 skull fractures, whilst Ritchie Russell (1949) mentions the occurrence of 45 supra-orbital nerve injuries and 8 infra-orbital in 1000 cases of head injuries. The supra-orbital lesions were mostly due to soft-tissue damage of the eyebrows. He mentions having seen a case of bilateral trigeminal destruction by damage at the foramen ovale. Tietze (1916) quoted Holbeck as saying that there were 4 trigeminal in 38 cranial nerve injuries in the Russo-Japanese War. It is evident that no important service will be served by any attempt to give a statistical basis to trigeminal injuries. The series now to be presented consists of 66 examples personally observed. (*Table I.*) No doubt some interest could be found in the scalp anæsthesiæ and paræsthesiæ that follow soft-tissue injuries, but they have been omitted since the purpose is to focus attention on injuries of the Gasserian ganglion itself, its roots, and those parts of its divisions which lie within the cranial cavity or in the facial bones. It will be demonstrated that these injuries are much commoner than is thought, and can be found from time to time if the clinician looks for them systematically. Some lesions are mild; their effects quickly pass away and their significance is not appreciated. A diplopia or a facial weakness impresses itself on both patient and observer, a slight facial numbness can be regarded as a vague contusional effect and is not further inquired into, even though it has a recognizable nervous distribution. However, some trigeminal injuries result in dense anæsthesia and are quite unmistakable.

Reference was made earlier to the compilation of Wilbrand and Saenger in their famous *Die Neurologie des Auges*. They collected 36 cases from the literature, of which 5 were due to gunshot wounds, 4 to penetrating injuries such as by a hay-fork or a stick, and 27 to fractures of the base of the skull. Seven in all developed neuroparalytic keratitis, a subject that naturally deeply interested those writers. In fact, all the trigeminal lesions, whether they were tumours, gunshot wounds, or injuries, were collected by them with the object of discovering how often keratitis occurred when trigeminal damage whatever its kind was present. Keratitis was very infrequent in the series presently to be described and since Wilbrand and Saenger's day much of its mystery has disappeared. It was said just now that trigeminal injuries have rarely been reported, yet in order to provide as complete a background as possible to the subject and to give credit to others where it is due it has been thought proper to make a fresh search of the literature even far back in time. This search has led to the finding of a further 50 cases of trigeminal injury, and because many of them were reported in journals or theses difficult of access it has been thought that it would be a convenience to others if they were tabulated (*see Tables II, III*). Further references will be made to this literature later in the paper.

Considerations of various kinds have motivated the reporters of cases. Usually they have described a single case, rarely as many as 2 or 3 cases. The largest collections have been gatherings from the literature with maybe not more than one or so of the writer's own cases. The great interest of French ophthalmologists in the ocular palsies consecutive to injuries, whether direct or indirect, to the orbit and its contents has led to the description of several cases in which injuries to the ophthalmic division of the trigeminal nerve have been present, but have interested the observers less than oculomotor lesions and mainly when trophic changes in the cornea have resulted. Such collections were those of Ferron (1900), Roche (1904), and Plichon (1924). Le Merdy's contribution (1917) contained no trigeminal cases, but was important in drawing attention to the consequence of fractures involving the orbit and to the intramuscular hæmorrhages which lead to transient diplopias after head injuries. The interest of all these writers had been excited by the oculist de Lapersonne (1902) who had been amongst the first to report them. The syndromes of the orbital apex became almost a special province of French

neuro-ophthalmology, as the writings of, for example, Dejean (1927) demonstrate.

An interest in trigeminal injuries of an entirely different kind was derived from the part which French surgeons played in elucidating the mechanism of skullbase fractures. Fractures of the petrous bones greatly interested several, notably Félizet (1873), Chipault and Braquehaye (1895), Chevrier (1905), and Duret (1919). Fractures of the petrous apex

Table I.—MATERIAL
(66 *Cases*)

Category	*Structures Injured*	*Number of Examples*
Penetrating Wounds (14 cases) :—		
A. Intracranial	1. Gasserian ganglion	7
	2. Maxillary division	2
B. Extracranial	1. Maxillary division	5
	2. Mandibular division	1*
Blunt Head Injuries (52 cases) :—		
A. Intracranial	1. Gasserian ganglion	9
	2. Ophthalmic division	2
	3. Maxillary division	1
	4. Mandibular division	1
B. Extracranial	1. Maxillary division or infra-orbital nerve	32
	2. Mandibular division	7

* Had ganglion injury on opposite side.

are very naturally liable to cause trigeminal root or ganglionic injury and Roger, Zwirn, and Ourgard (1922) used the available experimental and necropsy material to explain very clearly the association of trigeminal damage with facial palsy and deafness, as an index of the course of the fracture line. Some further remarks on these subjects will be found later in the present communication. By comparison not only with the French but also with the German contributions of von Wahl on bending and bursting fractures of the skull, and of Messerer on the identity of the fracture line and the direction of the violence, it may be reflected how small a part British surgeons have played in the mechanics of the bony skull and its injuries. Rawling (1912) it is true made a series of careful observations, but not of an experimental kind. Ritchie Russell and Schiller (1949) have, however, recently added some important studies of this nature.

In the pages that follow, a series of 66 trigeminal injuries personally observed will be reported. There were 16 lesions of the Gasserian ganglion or of its root (the rare type) and others of its peripheral divisions. The largest single group is comprised of injuries of the maxillary division, a group which, bound up as it is with the mechanics of maxillary fracture, is more interesting than would at first sight appear. The gunshot wounds will be dealt with first, wounds in which skull fracture is a necessary accompaniment of trigeminal damage. In the second and larger group caused by blunt injuries a cranial fracture was usually verified. The case histories will disclose the nature of the injuries.

GUNSHOT WOUNDS

During and shortly after the first world war one of the writers met with 5 cases of penetrating wounds affecting the trigeminus or its branches; 2 of these involved the ganglion itself and 3 the maxillary divisions. These remained unpublished. By chance it happened that the first penetrating wound of the head seen by him in the second war was a soldier, well in all other respects except for a complete anæsthesia of the right side of the face and third-nerve palsy. The cause was a bomb fragment lodged at the tip of the petrous bone. The second of the writers had opportunity to observe and operate upon a large series of head wounds overseas. From amongst these, fresh examples have been drawn.

PENETRATING HEAD WOUNDS INJURING THE GASSERIAN GANGLION
(7 *cases*)

The accounts of all these cases are briefly given; there is little to record except bare facts of the anatomical lesions.

Case 1.—**Bullet-wound left Gasserian ganglion. Transitory palsy of left oculomotor nerve. Complete anæsthesia of left face and paralysis of masticatory muscles.**

Sgt. McD., aged 31, had been wounded on Aug. 13, 1915, by rifle bullet. He was unconscious only a few minutes and walked to the dressing station. No operation was done. From the moment of injury he had complete anæsthesia of the left side of the face; when seen five years later it was partly recovered, not that the area of numbness had shrunk, but it was less dense. There was a healed scar of entry in the mid-temporal region, 1¼ in. behind and above the left external angular process. For some weeks after the injury he had ptosis and diplopia, but this recovered spontaneously. Radiographs showed a rifle bullet lying obliquely nose downwards in the base of the skull on the left. Its point lay immediately in front of the apex of the petrous bone and appeared to be lightly embedded in the cranial base.

It was possible to make contact with this patient twenty-five years after injury. A complete motor palsy of the fifth nerve was present in 1920 and still remains, so that the jaw swings to the left when the mouth is opened. The anæsthesia to touch, pain, and temperature affects the cheek and upper lip, the nostrils, the lower lip and inside the mouth, upper and lower gums, the palate, and left side of the tongue. There is hypo-æsthesia of the forehead. The corneal reflex is diminished, but although a number of fibres of the first division escaped injury there have been several attacks of mild neuro-paralytic keratitis resulting in nebula and loss of acuity for reading.

Comment.—The position of the missile and the distribution of the anæsthesia maximal in 2nd and 3rd divisions make it likely that the bullet cut into the ganglion at its front end. The oculomotor nerve was temporarily put out of action and other ocular nerves may also have been involved at first. In spite of some recovery the face was still as numb many years later as if a surgical resection of root fibres or partial gasserectomy had been carried out.

Case 2.—**Penetrating G.S.W. skull, injury to right Gasserian ganglion. Patchy anæsthesia in all three divisions.**

Lieut. M., aged 26, wounded May 15, 1918, by fragment of shell which passed below the brim of his steel helmet, and entered the right temporal fossa immediately in front of the tragus. Radiographs showed a large fragment which had remained lodged at the petrous tip intracranially in the situation of the Gasserian ganglion. The wound was excised and the bone fragments were removed. Patient had a post-traumatic amnesia of twenty-one days; no details of this period available. On recovering

consciousness he observed that the whole of the right side of the face was numb. When seen two years later he had minor recurrent extracranial infection in the wound easily cured by incision and removal of a small shell fragment from the parotid. The chief clinical feature was anæsthesia of the right trigeminal field denser in some parts than others, but with a three-division distribution such as could only have resulted from an injury to the Gasserian ganglion or its root. Radiographs confirmed the presence of shell fragment, 1·5 cm. square, lodged at the petrous tip. There were paræsthesiæ in paralysed. A former complete palsy of the third nerve could be deduced from the patient's story of original ptosis and external deviation of the eyeball. No operative treatment was undertaken.

Case 4.—**Bomb splinter, wound right Gasserian ganglion. Numbness right face and weakness of masticators. Palsy right 3rd nerve.**

Pte. E. E. S., was wounded by a bomb splinter May 21, 1940, which entered in the right malar region (*Fig.* 698, **4**). He was semi-conscious for half an hour, but walked to

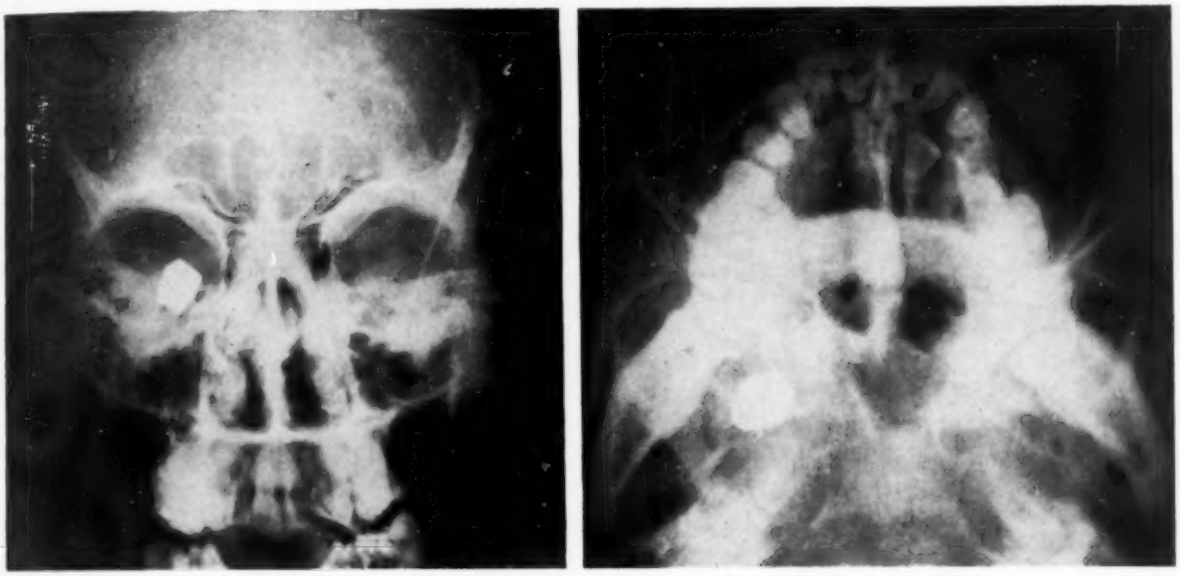

FIG. 694.—*Case* 4. Bomb fragment lying at site of right Gasserian ganglion.

the insensitive area, tingling, and a sensation as of swelling as is so common in anæsthetic zones. At first it was painful, but two years later there were no neuralgic pains and the numbness did not greatly trouble him. The cornea was anæsthetic but clear, and vision was normal. The masseteric muscles were not paralysed. It was impossible to say whether the motor 5th had been spared originally or had recovered since. This officer was lost sight of, but it is now learned that he died in 1946 of Hodgkin's disease, sensation in the face having remained much as above.

Case 3.—**G.S.W. Right Gasserian ganglion. Paralysis of right 3rd and 4th cranial nerve; anæsthesia 1st and 2nd divisions of trigeminal nerve. Neuroparalytic keratitis right cornea.**

Pte. W. S., aged 30, wounded Oct. 27, 1917, by shell fragment entering just behind external angular process, followed by ptosis and numbness of the right face. Seen five years later, complaining of numb right face, diplopia, and trouble with cornea. Healed scar in right temple. Radiographs showed shell fragment, 1 cm. square, lying in the cavernous sinus, below and anterior to the tip of right anterior clinoid process.

There was dense anæsthesia in the full territories of the 1st and 2nd trigeminal divisions down to and including the upper lip. He did not think it had altered much since 1917; he had got used to it. Patient had had recurrent attacks of neuroparalytic keratitis requiring treatment and had developed corneal opacities sufficient to reduce vision in the right eye to hand movements. Vision left side 6/9. Fundi normal. The eye was now open but the palpebral fissure was narrower on the right; there still remained paralysis of the right upper and weakness of the inferior rectus muscles; the superior oblique was

the dressing station. Since then he has had pain in the right side of the face, blurred vision, and right-sided ptosis. There was epistaxis from the right nostril. He was admitted to an E.M.S. Special Head Injury Centre (Winwick) ten days later. The relevant findings were: (1) complete anæsthesia in all divisions of the right trigeminus, including palate and gums; (2) loss of power in the right masseter; (3) palsy of the right oculomotor nerve. There was a mildly infected punctured wound 0·5 cm. below and 1·5 cm. lateral to the external canthus on the right malar bone. On lumbar puncture the C.S.F. was yellow, the pressure normal. Radiographs showed a solitary metal fragment lying close to the base of the skull immediately above the foramen ovale, confirmed on basal projection (*Fig.* 694). The right trigeminal field was at first completely anæsthetic, but although the numbness persisted after a month there were two areas denser than the rest, one on the right forehead and the other on the right upper lip and right ala nasi. Seen ten years later because of dull aching pain in right forehead, cheek, and side of nose, which had troubled him variably for some years. Ocular movements now of full range, right pupil slightly smaller than left, reactions sluggish. Corneal reflex absent on right. Trigeminal anæsthesia persists in all three divisions. Radiograph showed fragment of metal as before.

Case 5.—**Penetrating wound left temple. Complete anæsthesia left trigeminal distribution, right hemiparesis, and hemianæsthesia. Left abducens palsy. Dysarthria. Transient right hemianopia and dysphasia.**

Pte. A., wounded by H.E. shell Feb. 29, 1944, dazed but not unconscious. Wound of entry midway between left external auditory meatus and angular process

immediately above zygoma. Admitted No. 5 M.N.S.U. Italy. Radiograph showed shell fragment 8 mm. diameter lying 1½ cm. above and behind posterior clinoid process. Patient roused when addressed, spoke haltingly with marked dysarthria. Emotionally upset, cried readily. Hemianopia in right visual field. Complete left-sided trigeminal anæsthesia, masticatory muscles weak on left. Incomplete ptosis left eye, palsy left superior and external rectus muscles. Pupils small, reacted to light, left smaller

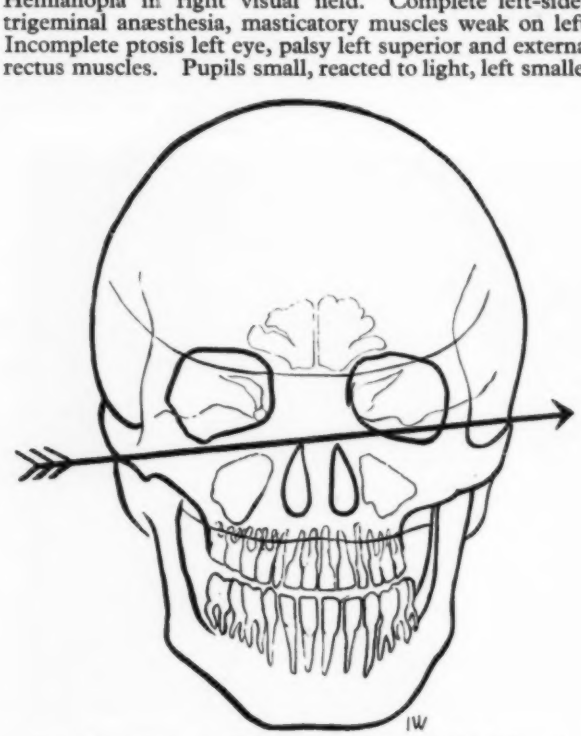

FIG. 695.—*Case* 6. Traject of missile producing bilateral trigeminal injury, right extracranial, left intracranial.

than right. Both corneal reflexes absent; complete anæsthesia left trigeminal field, pin-prick felt as a touch on right side of body including face. Right facial palsy of central type, right arm and leg paretic, power and sensation normal in left trunk and limbs.

At operation on March 4, 1944, indriven bone splinters were removed from left temporal lobe; the track was found across the inferior horn of left ventricle. No attempt made to find missile. Primary wound healing. Ten days later, ptosis and weakness of left upper rectus had disappeared; abducens palsy persisted. There were gross nystagmoid jerkings on attempting to look upwards, sensory loss of left face persisted, except in third division; masticatory muscles regained power. Sensory loss on right trunk and limbs persisted (no record of right face and head). Movements returned to the right arm and leg, but were weak and clumsy. Speech explosive and dysarthric. No dysphasia. Hemianopia recovered. Still emotionally labile a month after wounding; on slightest provocation would go into fits of helpless laughter. When these subsided he admitted that he had not felt in the least amused.

Comment.—The missile in this case evidently traversed the left temporal lobe, damaged the Gasserian ganglion or its root, and went on to injure the midbrain or upper margin of the pons. It is impossible to be sure whether the retained missile had reached its final destination direct or whether in the last few centimetres of its course, when it was rapidly decelerating, it may not have rebounded upwards from the bone. The latter happening seems very probable in this case, because a straight line from the wound of entry to the resting position of the shell fragment, as seen on the radiographs, would not implicate the trigeminal apparatus.

Case 6.—**Traversing wound cranial base. Bilateral trigeminal injury: extracranial damage right third division; intracranial lesion left Gasserian ganglion, anæsthesia all three divisions; left facial palsy; C.S.F. otorrhœa, left.**

Pte. M. Nature of missile not known, operated upon before admission to No. 5 M.N.S.U. Traversing wound across head; minute entry wound right cheek below zygoma, ¾ in. anterior to porus externus; exit wound on opposite (left) side, ½ in. above zygoma at mid-point between porus and external angular process (*Fig.* 695). The missile was rising as it crossed, tearing into the skull base on the left side, driving bone chips into the left temporal lobe. These had been removed elsewhere and a fascial patch applied as a left-sided C.S.F. otorrhœa was present. Post-operative examination: Anæsthesia was found in area of right third division and paralysis of masticatory muscles (i.e., on side of entry) evidently an extracranial injury for no bone damage could be found in radiographs of this side; in addition, complete anæsthesia left trigeminal distribution, again with paralysis of masseter and pterygoids. Bilateral jaw drop. Difficulty in talking because of bilateral anæsthesia of tongue. Complete left facial palsy; deaf in left ear. No recovery of sensation when evacuated a month later.

Comment.—This example is very unusual, for here a missile (probably a bullet) passed laterally across the skull base causing damage to one third division after it had left the foramen ovale, and then crossed the midline to enter steeply into the skull and injure the other Gasserian ganglion and petrous bone. The bilateral jaw drop and anæsthesia of the tongue caused great difficulty in talking and in taking food.

We owe the records of two cases (*Cases* 7 and 25) to the kindness of the late Colonel Stewart, R.C.A.M.C. of the Canadians' Neurosurgical Hospital at Hackwood Park.

Case 7.—**G.S.W. traversing left orbit; blind left eye; paralysis of 3rd, 4th, 6th cranial nerves and complete anæsthesia left trigeminus, injury to left Gasserian ganglion.**

Pte. G. R. (B.143029), aged 26, was wounded by a rifle bullet Sept. 9, 1944. The bullet entered the left orbit inferiorly and traversed the skull to emerge above and behind the left external auditory meatus, where it could be felt beneath the skin (removed Nov. 6, 1944). The eyeball was intact; fundus showed traumatic choroido-retinitis, involving the macula. Optic nerve later pale, vision nil. There was complete left-sided ophthalmoplegia. In addition the whole left trigeminal field was anæsthetic. The patient recovered and returned to Canada, later history not known.

X-ray films showed comminution of left greater sphenoidal wing, fracture of lamina papyracea of left ethmoid, hole of exit in lateral part of floor of middle fossa, linear fracture left temporal squame.

Comment.—The injury was evidently caused by a spent bullet, judged by the injury to the nerves in the cavernous sinus and to the Gasserian ganglion (*Fig.* 696) relative to the bullet's ports of entry and exit. It is clear that it must have been deflected by the resistance of the cranial bones.

This case is paralleled by those of Weir Mitchell (1872) and Lagrange (1918).

G.S.W. causing Intracranial Damage to Second Trigeminal Division

The next two cases are remarkable in that in neither case had the main injuring fragment penetrated the dura. In one some small and less deep pieces entered the temporal lobe. They must, of course, have cut some sort of a gutter in the skull

base, but the precise course of missiles entering the skull base or through the cheek can rarely be convincingly demonstrated.

Case 8.—Italy, 1944. Pte. S. Small entry wound left temple just below pterion. The only neurological sign was anæsthesia in the left 2nd division, including the hard palate and all the soft except for a fringe posteriorly. X-ray film showed three small H.E. shell fragments, two deep to entry, one at level of floor of middle fossa in line with medial third of orbit. At operation the latter fragment was extradural and lay against the cranial opening of foramen rotundum. The remaining two metallic fragments had penetrated a short distance into the temporal lobe. All were removed.

Case 9.—Italy, 1944. Pte. O. Shell fragment, ½ in. long ¼ in. wide, entered the right temple just above zygomatic arch and slid along the floor of the skull up to foramen rotundum. On elevating the temporal lobe

FIG. 696.—*Case* 7. Bullet traversing through left orbit to lodge beneath skin over mastoid. Complete left trigeminal anæsthesia.

extradurally to extract the metal it was observed that only the outer layer of the dura was lacerated. Total anæsthesia in the whole 2nd division supply was present before operation and persisted until the patient was discharged.

EXTRACRANIAL G.S.W.S OF MAXILLARY DIVISIONS (5 *cases*)

There are 5 cases in this group. The 2nd division is very prone to damage at some point in its course by gunshot wounds of the face, and it is highly probable that our 5 cases are but a tithe of those which actually occurred. In many of the severer injuries where there is severe comminution of the facial bones and great loss of tissue the nervous interruption is a minor phenomenon likely to escape recognition or else the tissues which the division innervates are entirely lost. Facial wounds requiring repair pass into the hands of the plastic specialists whose interest is naturally in the problem of facial reconstruction and the anæsthesia is rightly considered both by them and by the patient to be of secondary importance. The numbness caused by injury of the second division appears in pure form only in punctured or perforating wounds causing

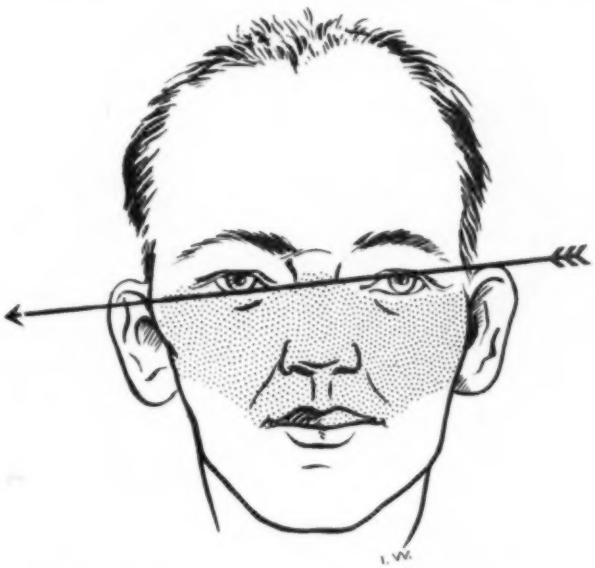

FIG. 697.—*Case* 10. Bullet traversing back of left orbit to right malar. Section of both maxillary divisions. Palatal anæsthesia.

little disturbance to the bones or soft parts. This is the type which the neurologist is more likely to see.

Case 10.—**Traversing bullet wound across face; bilateral anæsthesia of cheek, nose, and upper lip.** Pte. H. A., aged 45, bullet entered left anterior temporal region 2·5 cm. behind the orbital margin on May 29, 1915, emerging through body of zygoma below external angle of right eye. Five years later there was a large butterfly area of anæsthesia in the central part of the face (*Fig.* 697). The nostrils and septum nasi were numb as far as they could be reached with a probe. The upper gums and palate were also numb, indicating section of the second divisions close to their exits from the cranium.

Case 11.—**Shell wound of left temporal region into the orbit; transient numbness of left upper lip and cheek.** Pte. J. H., aged 29, wounded Oct. 22, 1917, one shell fragment destroyed left eye. A second entered left cheek over infra-orbital foramen. For some months after the injury the cheek, lips, and gum on the left side were still numb but had recovered fully when seen three years later. Evidently the injury to the nerve was purely contusional.

Case 12.—**Wound left cheek. Missile in posterior ethmoidal cells. Anæsthesia in area of infra-orbital nerve.** W. S. T., Home Guardsman, admitted to Manchester Royal Infirmary under Professor Victor Lambert Aug. 22, 1941. Accidentally injured by fragment of hand-grenade. There was a wound in the left cheek 2 cm. below the orbital margin, just lateral to the nose. Anæsthesia in the full distribution of the infra-orbital division and its palatal branches. Radiograph: A small metallic fragment (0·8 cm. across) lying deep in the left face;

subsequent lipiodol studies proved it to be in the posterior ethmoidal cells. Three weeks later re-admitted because of infection. Bomb fragment successfully removed from the posterior ethmoid cells by Professor Lambert. Subsequent course was smooth, but the anæsthesia was still present and little diminished ten years after the injury.

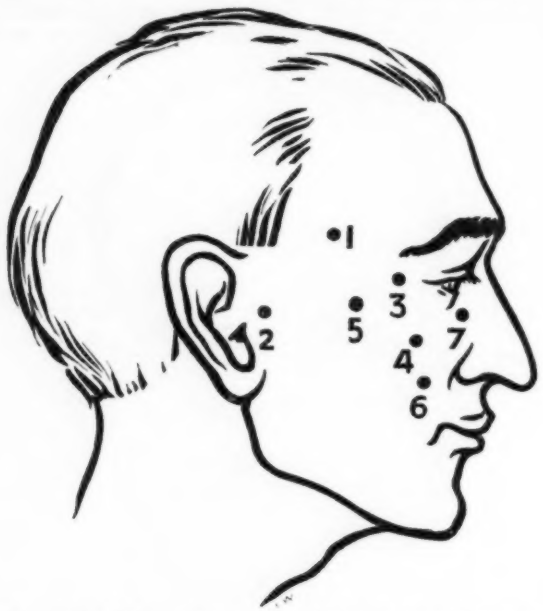

FIG. 698.—Points of entry of missiles injuring Gasserian ganglion (7 cases, numbers as in text).

Case 13.—**Traversing wound left cheek. Partial numbness in the infra-orbital nerve.**

Pte. F. W. was wounded by a shell fragment that entered 1·0 cm. below the centre of the left orbit and came out immediately above the left zygoma. Three years later he was still densely anæsthetic in an area supplied by the infra-orbital nerve.

Case 14.—**Shell splinter wound right cheek, 1916. Temporary anæsthesia infra-orbital distribution; thirty-three years later residual anæsthesia in superior dental area.**

Pensioner P. T., aged 55. Facial wound 1916. Anæsthesia right cheek, lip, and three upper teeth. Thirty-three years later the anæsthesia had decreased to a minimal difference between the upper lips on the two sides and a more pronounced numbness of the right alveolar process, gum and teeth on right.

Precisely similar cases were reported by Uhtoff (1915) and Purves Stewart and Evans (1916). Mention may here be made for the sake of completeness of a case in which the sensation in the left half of the tongue was abolished by section of the lingual nerve by a bullet entering the left cheek. There were present also palsies of the left vagus, glossopharyngeal, spinal accessory, and hypoglossal nerves as well as suboccipital arteriovenous fistula of the vertebral artery successfully dealt with (G. J.) by obliteration.

GENERAL COMMENT ON MISSILE INJURIES

The cases of injury of the Gasserian ganglion recorded above illustrate the pranks played by missiles in inflicting damage on deeply situated structures in a selective manner. It seems odd that chance should bring a bullet or shell fragment into damaging contact with the Gasserian ganglion so accurately that the carotid artery, lying so little deeper, was not opened. It might be taken as a fair assumption that when both root and artery are divided the patient dies on the spot, but it has to be remembered that some carotico-cavernous fistulæ have resulted from pieces of shell or bullets with survival of the subjects (see some discussion on this matter later). The sites of entrance of the missiles in the seven ganglion injuries have been plotted in *Fig.* 698. As would be expected, they lie conveniently for an approach, sometimes unorthodox, to the ganglion. Of the ganglion injuries themselves only 4 of the 7 were complete as judged by the anæsthesia in all three divisions. In three others two-thirds of the ganglion was damaged. In one remarkable case (*Case* 6) the 3rd division was cut extracranially on one side whilst the whole ganglion on the other was

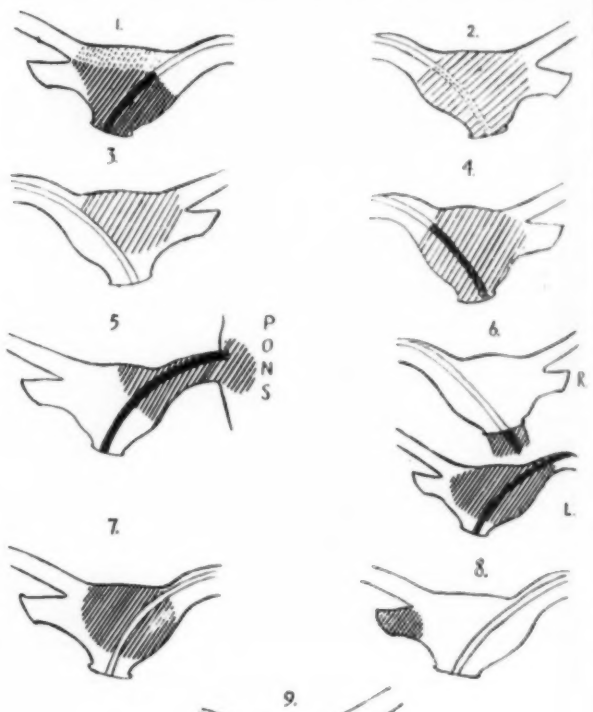

FIG. 699.—Diagram of estimated extent of ganglion injury in the missile injuries. Motor branch black if injured. Hatching denotes degree of anæsthesia

put out of action. Motor root lesions seemed to follow expectations considering the part of the ganglion traumatized. The lesions have been schematized for the reader's convenience in *Fig.* 699. We have no evidence of the appearance of the lesions either at operation or autopsy (none died), but this is no great loss since it can be inferred. It will be recognized that the sizes and extent of the ganglionic injuries depicted in the diagram represent probabilities based on the physiological paralyses rather than precise anatomical data of laceration or contusion.

Yet, judged from the transitory effects of slight damage to the ganglion after unsuccessful attempts to cut the sensory root or perform partial ganglionic excision by unpractised hands, we can be quite sure that a lasting sensory loss indicates destruction of nerve cells or the true section of root fibres. In one case at least it seemed likely that the root rather than the ganglion had been the tissue injured (*Case* 5). Palsy of the motor fifth was noted in 4 of the ganglion injuries. In *Fig.* 699 these have been plotted. Their significance in terms of the site or depth of the lesions is obvious, and equally true of those consequent on blunt head injuries. It is impressive that durable anæsthesia should be an even greater feature of the gunshot injuries than of the blunt injuries. Neuralgia, even of the atypical paræsthetic type, was an infrequent consequence. The men complained of their numb faces more than do persons deliberately denervated for paroxysmal neuralgia. But a numb face is a positive and annoying feeling for persons previously in good health and with no antecedent pain to turn a numb face into a comparatively pleasurable possession.

As for coincidental lesions of other cranial nerves, all but one had them. This will be found true of the cases in the literature, as in the present writers' series. They were grouped as follows: 3; 3 + 4; 3; 6; 7; 2, 3, 4, 6. In one case there was contralateral hemiparesis and hemianæsthesia. Only 2 cases had keratitis whilst under observation. The involvement of other cranial nerves besides the trigeminal is not to be wondered at; indeed an injury so selective that it picked out the trigeminal alone would be, though not impossible, the greater marvel. Our own *Case* 2 seems to be an example, but it is possible that early and recovered ocular palsies were not recorded in these notes of thirty years ago. Injury must be done to the brain in the transit of the missile through it to the ganglion. It may be minimal, in which case the missile has tracked straight to the ganglion through the skull base or through the orbit and ethmoidal cells. It is significant that the wounds of entrance in our cases and in those in the literature were mainly in the face or temple. The common high parietal and frontal wounds are very rarely indeed complicated by trigeminal injury.

In Tietze's contribution (1916) on injuries of the cranial nerves no new cases were added to the famous compilation of Wilbrand and Saenger (1901). At these dates only 7 instances of wounds of the trigeminus or its branches by missiles had, they thought, been recorded. These writers had, however, omitted two cases described by Weir Mitchell (1872), of which the first presented numbness of the right forehead and globus oculi with paralysis of the 1st, 3rd, 4th, and 6th cranial nerves. Post-mortem examination showed that all these nerves had been cut across at the back of the orbit by the passage of a pistol-ball from the right temple to lodge in the ethmoid bone. The second, a soldier, was wounded in the left cheek by a long-range shot at Gettysburg and the inferior dental nerve injured. The rifle ball lodged in the trapezius, whence it was extracted by W. W. Keen. The 25 cases, some missed by Wilbrand and Saenger, have been tabulated (*Table II*). In Lagrange's monograph on G.S.W. fractures of the orbit, there is mention of 7 examples of trigeminal divisional injury and 1 affecting the ganglion with denser anæsthesia, deeper in the area of the ophthalmic division than elsewhere. A shrapnel ball lay at the apex of the left orbit after entering the temple. This patient was blind on the ipsilateral side, with a total ophthalmoplegia as well. Another case is spoken of as presenting " anæsthesia of the left part of the face ", but no details are given. In 4 further cases the anæsthesia was of the maxillary division, in 2 bilaterally (as in our *Case* 10). One case was of exceptional interest: A shrapnel ball entered the outer angle of the orbit, causing immediate blindness in the ipsilateral eye, the eyeball itself being intact. In addition the cornea, and the cornea alone, was insensitive, neuroparalytic keratitis resulting. This must be a very rare injury. We have seen only 1 example; the cause there was blunt injury not a missile. As for extracranial injuries of divisions, little more can be said than that when a missile passes through the structures of the face drilling or splintering the bones and dividing the bony canals in which nerve-trunks so frequently travel, the prospects of regeneration must be lessened. The canals are broken into and the bony walls permanently infracted; only 1 of our cases showed a complete recovery, the remainder were nearly if not quite as numb from ten to thirty years afterwards as on the day of battle.

Table II.—TRIGEMINAL INJURIES

Author	*Trigeminal Divisions* First	Second	Third	*Other Cranial Nerve Injuries*
Gunshot Wounds (23 Cases)				
Mitchell, Weir (1872)	+	+	+	3 4 6
	o	o	+	o
Maréchal (1897)	+	o	o	
Nathan (1902)	+	+	+	1 2 on other side
Morestin (1915)	o	+	+	7
Uhtoff (1915)	+	+	o	o
	o	+	o	2
Stewart and Evans (1916)	o	+	o	
Pachantoni (1917)	o	+	+	7 9 10 12
Lagrange (1918)	+	+	+	2 3 4 6
	o	+	o	o
	4 such cases, 2 bilateral			
	+	o	o	
Pastine (1918)	+	+	+	1 2 3 4 6 7 8
Albo, Wencelao-Lopez (1920)	+	+	+	o
Plichon (1924)	+	o	o	3
	+	o	o	3
	+	o	o	3 4 6
Quirin (1928)	+	+	+	3 7
Licux and St. Martin (1943)	+	+	o	o
Gaudiosi (1947)	o	o	+	10
Stab Wounds (2 Cases)				
Verdelet and Aubaret (1900)	+	o	o	2 3 4 6
Goldzieher (1906)	+	o	o	2 3 4 6

TRIGEMINAL LESIONS IN BLUNT HEAD INJURIES

BASAL FRACTURES

Although trigeminal ganglionic lesions are uncommon accompaniments of fractures of the cranial base we are able to record 9 instances seen within the last few years. Another group important in its own right is the injury to the maxillary or infra-orbital nerves in facial fractures. These latter are quite common and are only surpassed in frequency by injuries of the supra-orbital and other cutaneous nerves in scalp wounds as described by Friedman and Merritt (1944).

Ganglion Injuries
(9 *Cases*)

Case 15.—**Blunt head injury. Total ophthalmoplegia right (anæsthesia ophthalmic division), partial right trigeminal ganglion injury.**

Miss H. M., aged 20, was seen at Park Prewett Hospital through the courtesy of the late R. H. Jocelyn Swan. She had been injured in an air raid in 1941, when her head was struck in the fall of a building. She remained unconscious for five days. The local signs of injury

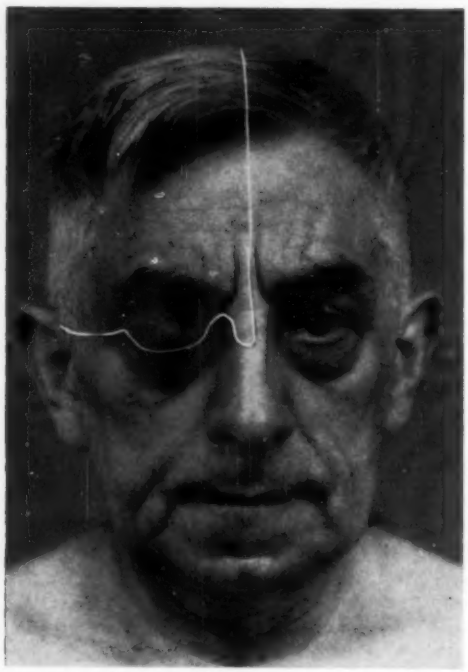

Fig. 700.—*Case* 16. Fractured skull. Injury to ophthalmic division (reprinted from *Proc. ophthal. Soc. U.K.*).

were: (1) hæmorrhage into the right orbit; (2) total ophthalmoplegia, right; (3) absence of the right corneal reflex and hypo-æsthesia of the forehead back as far as the inter-auricular line. The pupil was dilated and fixed. Three months later conditions were improving, but some weakness of the superior and internal recti remained. The pupil was inactive and there was the usual difficulty with reading from diplopia. The optic disk was normal. The cornea remained insensitive, but the hypo-æsthesia of the forehead was giving place to areas painful to pinprick. The other divisions of trigeminus were normal.

An example of injury to the ophthalmic division similar to but more severe than the foregoing was the case which follows. It has already been reported (Jefferson, 1953) and will be given in the briefest outline. Eight will be found in the synopsis (*Table III*).

Case 16.—**Fracture anterior cranial fossa. Total right-sided ophthalmoplegia, internal and external. Blind right eye. Dense anæsthesia in whole supply of first trigeminal division.**

I. J., aged 61, M.R.I./O.P., 1953, was injured in a motor-car collision in 1952, and was unconscious for 8 hours. When the swelling of the lids subsided the right eye was found to be blind and the eye-ball immobile, the pupil wide and fixed, the globe, upper lid, and forehead stone numb (*Fig.* 700). Two years later the eye was still blind but it was open and the globe moved a little in all directions. The anæsthesia of the forehead had greatly diminished, but pinprick was unpleasantly painful and light touch not so clear as on the left. The site of the injury here was no doubt at the anterior end of the cavernous sinus; it belongs to the category described by Dejean (1927) as "syndrome paralytique du sommet de l'orbite", a subject discussed in the paper in which this case originally appeared. The recovery of sensation speaks against the ganglionic site of the lesion, but its incompleteness indicates the severity of the tear of the ophthalmic division.

Case 17.—**Third-nerve palsy. Temporary anæsthesia of all three trigeminal divisions on left.**

W. D., aged 46, O.P. 13491, fell from cycle on July 26, 1942, admitted to Northwich Infirmary unconscious with left frontotemporal hæmatoma and subconjunctival hæmorrhage. Ptosis left upper lid, paralysis left third nerve, with dilated fixed pupil and numbness of whole left face. When seen two months later the anæsthesia was lessened in degree, cotton-wool and pinprick being recognized, but was abnormal in quality in all three divisions; corneal reflex present but feeble. Motor root acting. The oculomotor palsy persisted. No fracture line could be detected in skull radiographs. There was no scalp wound. The anæsthesia disappeared in 6 months save for a small strip along the side of the nose and a diminished corneal reflex indicating that little destruction of trigeminal tissue had occurred. The injury was, by inference, a ganglionic contusion, if such a term may properly be used in these circumstances, leaving a residual anæsthesia only in a part of the first division.

Case 18.—**Blunt head injury. Brain-stem and right trigeminal injury, total anæsthesia right face and head. Neuro-paralytic keratitis. Bilateral abducens paresis. Left hemiparesis.**

T. C., aged 9, admitted Manchester Royal Infirmary, March 3, 1946, having been knocked down by a horse and cart 6 hours previously. He was carried home screaming and confused, but is said to have been conscious for a short time. Restless on admission, would not respond to questions, his lids were closed, the eyes deviated to the right, both temporal fossæ were swollen and bruised, there was bleeding from right ear. Left hemiparesis, left humerus fractured, limb motionless. Left extensor plantar response, right flexor. Pupils equal. No corneal reflex on right. L.P., March 19—50,000 R.B.C. Pressure 280 mm. March 20, four burr-hole explorations disclosed severe bruising of cortex in left parietal region, no massive clot found. On March 27, ulceration observed in the right cornea. Both eyes remained deviated to the right for two weeks. He remained in the same state and could not be induced to swallow. A nasal tube was inserted and he was tube-fed for a fortnight, when he became more co-operative and finally recovered.

When the patient was sufficiently responsive to allow of full examination it became demonstrable that he had a complete anæsthesia of the whole right trigeminal territory as dense and as complete to all sensory tests as if a complete section of the trigeminal root had been deliberately carried out. The mucous surfaces were equally anæsthetic. There was a narrow band-like opacity across the middle of the cornea, corresponding to the area that had remained unprotected by the lids as he lay so long with the eyes part open. The corneal reflex was completely lost on the right. There was no evidence of injury to the corresponding spinothalamic tract. There was paresis of both abducens nerves more pronounced on the left. Palatal and tongue movements were normal. There was ataxia of the right arm and leg together with slight nystagmus, but it passed off in 5 weeks. The right motor fifth was impaired but some contraction was palpable in the masseter, though it was not so powerful as on the left. The jaw deviated to the right on opening the mouth. In addition the patient

showed a left-sided hemiparesis, most dense in the face and arm and much less so in the leg. Six weeks after injury the left arm was still flaccid and motionless, the lower limb was moved with fair power.

Left plantar reflex was still extensor, left abdominals absent. Somatic sensation was but little impaired, joint sense was near normal, pin prick was felt. Three years later his condition was the same.

Comment.—The right trigeminal injury, the patient's inability to swallow for so long, and the right cerebellar ataxia indicate brain-stem damage. It is probable that the trigeminal root was sheared off by rotation or traction at the petrous tip.

Case 19.—**Bursting fracture of skull base, head squeezed in pit accident. Bilateral trigeminal injury. Carotico-cavernous fistula right. Left facial palsy, right abducens palsy.**

A. A., (76/49), aged 38, miner, was admitted to the University Neurosurgical Service, March 23, 1949, on advice from the Nottingham General Hospital, where he had been taken originally in January, 1948. Patient's head had been crushed between two tubs of coal in the pit. He bled from both ears and from the nose. Patchy recollection of next two weeks. On recovery noticed diplopia and a pulsating noise in his head. It was discovered that he had a left facial paresis, right abducens palsy, and carotico-cavernous aneurysm; his right common and internal carotids were tied and a clip put on the right internal carotid intracranially in March, 1949. The point of present interest is that originally both sides of his face were found to be numb in the trigeminal distributions. When seen 15 months after the accident he still had middle-ear deafness on the left but the facial palsy had recovered, as had sensation to some extent, but there was still hypo-æsthesia in all three divisions on the left side and the same still existed in the upper two divisions on the right. Corneal sensation was diminished on both sides, for the corneals were sluggish and corneal pain was slight. The right trigeminal loss was rather more profound than the left. The patient complained that his lips felt swollen and dry; he had a trick of frequently moistening the right upper lip in particular with his tongue because the lips felt so strange. It could not be established that there was any real diminution in the secretion of saliva. He was sure that no improvement in sensation was taking place. On the left side all three divisions were about equally affected, both touch and pin were recognized but were faint, figure writing was not appreciated on the forehead on either side. The left motor fifth was still weak.

From the history of the injury it was clear that this was a bursting fracture of the skull base that crossed both middle fossæ and opened both tympanic cavities. The same thing happened in *Case* 20, but with less serious results. The distortion in the present case must have been considerable since the right carotid artery was torn, and it is interesting that the trigeminal injury on the right side though of lesser area was more dense than on the left, where the distribution was wider. The right abducens as well as trigeminal fibres were torn across, for the palsy of that nerve remained complete. The probabilities are that there were bilateral fractures of the petrous apices.

Case 20.—**Crush injury of skull. Anæsthesia of all divisions of left trigeminal nerve. Paralysis L. 6th, 7th, 8th cranial nerves.**

Spr. L., injured Aug. 28, 1944, said to have fallen off dock and head was caught between the dock wall and the side of a ship. Post-traumatic amnesia several hours. Admitted No. 5 M.N.S.U., Sept. 14, 1944, still drowsy but could be roused to conversation; fell asleep as soon as left alone. Complete left-sided anæsthesia in full trigeminal area, all three divisions; left motor fifth division acted weakly. He also had paralysis of left 6th 7th, and 8th nerves and slight weakness of the right arm. There was a perforation of the right tympanic membrane which led to otorrhœa and ear infection. A month later, when he was transferred to another hospital, the trigeminal anæsthesia was unchanged. Presumed injury at petrous tip.

Case 21.—**Closed head injury, no fracture, severe cerebral trauma; cerebellar signs, right trigeminal hypo-æsthesia in all divisions.**

Road accident Italy, May 7, 1945. During acute stage grasp reflex present in right hand, and relative lack of mobility right side of body with right positive Babinski. No blood in C.S.F., pressure 210 mm. Bilateral drill holes negative for subdural clot. A month later admitted No. 5 M.N.S.U. fully orientated but ataxic. P.T.A. 10 days. Complains of numbness right side of face, loss of taste right half of tongue, pharyngeal reflexes normal. Radiograph, no fracture of skull. R. lower facial weakness, hearing unaffected. Classical signs of cerebellar dysfunction on right limbs. Rapid nystagmus on fixation to either side. Plantars normal. Trigeminus: Incomplete sensory loss in all three divisions, right corneal reflex weakly present, corneal sensation greatly diminished. Patchy anæsthesia to cotton-wool, numb to pin in all divisions. Motor fifth acting.

Comment.—This is an incomplete trigeminal anæsthesia. It is uncertain at what point this injury occurred, but the characters of the sensory changes suggest the possibility of a partial sensory root lesion in the posterior fossa, perhaps even an intramedullary lesion. The signs of cerebellar injury support this view.

Case 22.—**Right complete ophthalmoplegia. Right 5th nerve lesion all divisions (motor and sensory). Right facial weakness, deaf R. ear. Right 9th and 10th palsies. Death. Post-mortem findings.**

Cpl. J. S. J. This N.C.O. was involved in a road accident on Oct. 19, 1944, and was admitted to No. 5 Neurosurgical Unit thirteen hours later. He had been seen by a medical officer an hour or so after he had been injured, and he was then "not unconscious, but dazed". He could move all four limbs, but the right side of his face was noted to move less well than the left. On admission he lay with his eyes closed and could only be roused to move for brief periods by painful supra-orbital pressure; occasionally he would reply to a question by saying "yes" or "no", but no history of the accident could be obtained.

The optic disks were flat. The right eye was slightly proptosed and immobile. The movements of the left eye were full in all directions except upward. The right pupil did not react to light either consensually or directly, but the left pupil reacted to both direct and indirect illumination. The right corneal reflex was absent and no response was elicited to pinprick in the whole area of distribution of the right trigeminal nerve. If the left side of the face was pricked he winced or moved his head away. The right masseter acted less well than the left. There was a total right facial palsy of peripheral type. He could not hear with the right ear and the right tympanic membrane was ruptured in its anterosuperior quadrant. Clear cerebrospinal fluid escaped from the ear. The palate moved over to the left, but posterior pharyngeal sensation seemed equal on both sides. When he spoke later the voice had a nasal quality and swallowing of fluids made the patient cough and splutter.

A radiograph of the skull was taken under field conditions, and although no basal fracture could be seen there was a collection of subarachnoid air in the interpeduncular cistern. Nineteen hours after the accident his condition had not changed. Further examination showed that he moved all four limbs, but the left limbs were weaker, the tendon reflexes were increased on the left, and both plantar responses were extensor. The superficial abdominal reflexes were depressed on the left.

For 48 hours he remained in much the same state. Three days after injury he was still drowsy, but he counted the examiner's fingers and gave his own name and regimental number. His sense of smell could not be tested. The pupils were equal and circular, neither reacted to light; accommodation reaction not tested. The fundi were normal. The left eye moved occasionally from side to side, but the right eye remained immobile. Facial and corneal sensation were still entirely absent on the right; the left masseter and temporal muscles contracted, whilst those on the right did not. Hearing was absent in the right ear. The cranial nerves excepting the right trigeminal were now normal and there was no difference in the power and tone of the limbs. Plantar reflexes were flexor. C.S.F. continued to flow from the right ear, but there was no neck stiffness and his temperature remained normal. On the fourth morning after injury he seemed a little better, but in the evening of the same day he became unresponsive and his temperature rose to 104°. Lumbar puncture revealed a heavily blood-stained C.S.F. without organisms or increase in white cells. He died 12 hours after the onset of this final phase, four days after injury.

POST-MORTEM EXAMINATION.—There was no abnormality in the chest or abdomen. The surface of the brain was free from hæmorrhage and from signs of meningitis. The convolutions were not flattened and there were no pressure cones. There were gross hæmorrhages in the midbrain which could only have occurred in the final phase of the illness.* There was a fracture crossing the skull base obliquely from left to right. *Fig.* 701 shows the complicated fracture so clearly that description is not necessary. Attention is drawn to the comminution of the fracture in the medial third of the right middle fossa, of the petrous tip, and of the basisphenoid. Nor should the separate right lateral frontal fracture be passed over, for the appearances combine to show the severity of the injury. Histological sections of the Gasserian ganglion and its root, prepared by Dr. Eugen Pollak (*Figs.* 702, 703), show not only the expected hæmorrhagic infiltration of the ganglion from internal disruption of its architecture but also rupture of some of the fibres of the sensory root with hæmorrhages in it. Dr. Pollak observed that some of the ganglion cells were already degenerating. Microscopy in this case, the only one of the series in which this was possible, shows damage of the expected kind. This, so far as the writers can find, is the first time that a torn trigeminal root has been histologically verified. It is important that rupture of the sensory root, an event theoretically possible, has actually been demonstrated.

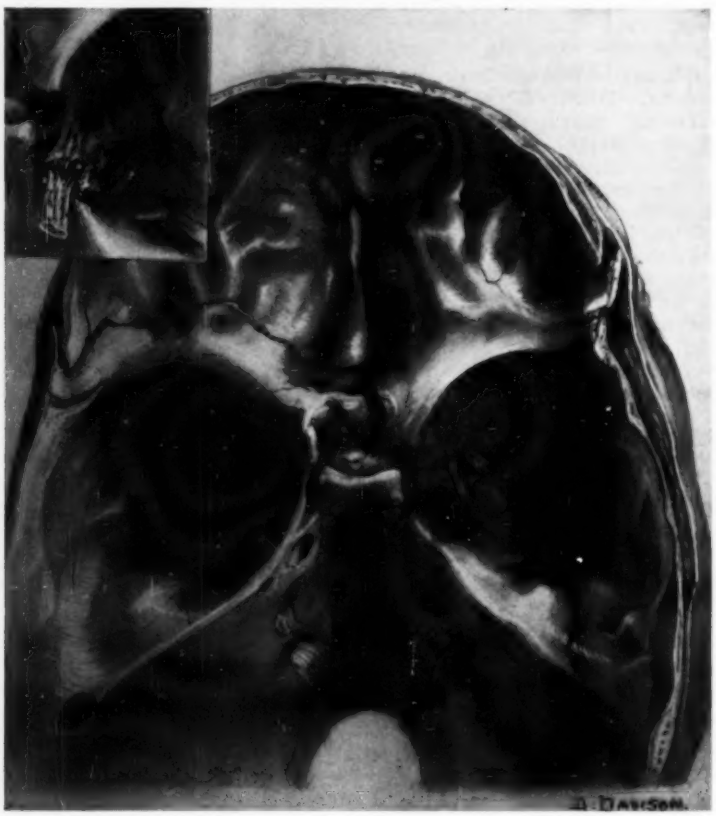

FIG. 701.—*Case* 22. The fracture at petrous tip and foramen lacerum. *Inset*: trigeminal injury.

* A photograph of the midbrain lesions in this case was published as Fig. 4 in the paper by Kremer, Russell, and Smyth (1947). Their statement that the patient lived for two days is an error.

INTRACRANIAL PARTIAL TRIGEMINAL INJURIES

In the next 2 cases the injury fell particularly on one division, though in the first of them the lesion may well have been ganglionic, because the failure of nervous conduction to return suggests nerve-cell destruction.

Case 23.—**Crush injury of skull. Extensive basal fracture. Dense anæsthesia right third division and small patch of second division. Diplopia. Abducens paresis.**

J. W., aged 43, was admitted to the Manchester Royal Infirmary July 20, 1943, his head having been caught and

squeezed by a fall of stone from the roof whilst inspecting the coal face in a pit. It required six men to lift the stone off. He did not lose consciousness and was instantly aware of the anæsthesia, which was as dense as that obtained by a successful nerve-block by novocain or alcohol. The lack of cerebral damage, the experimental quality of the manner in which the nerve was injured by squeezing the skull makes this case particularly interesting. It illustrates so clearly the perhaps obvious fact that it is the cranial distortion by squeezing and the torques and

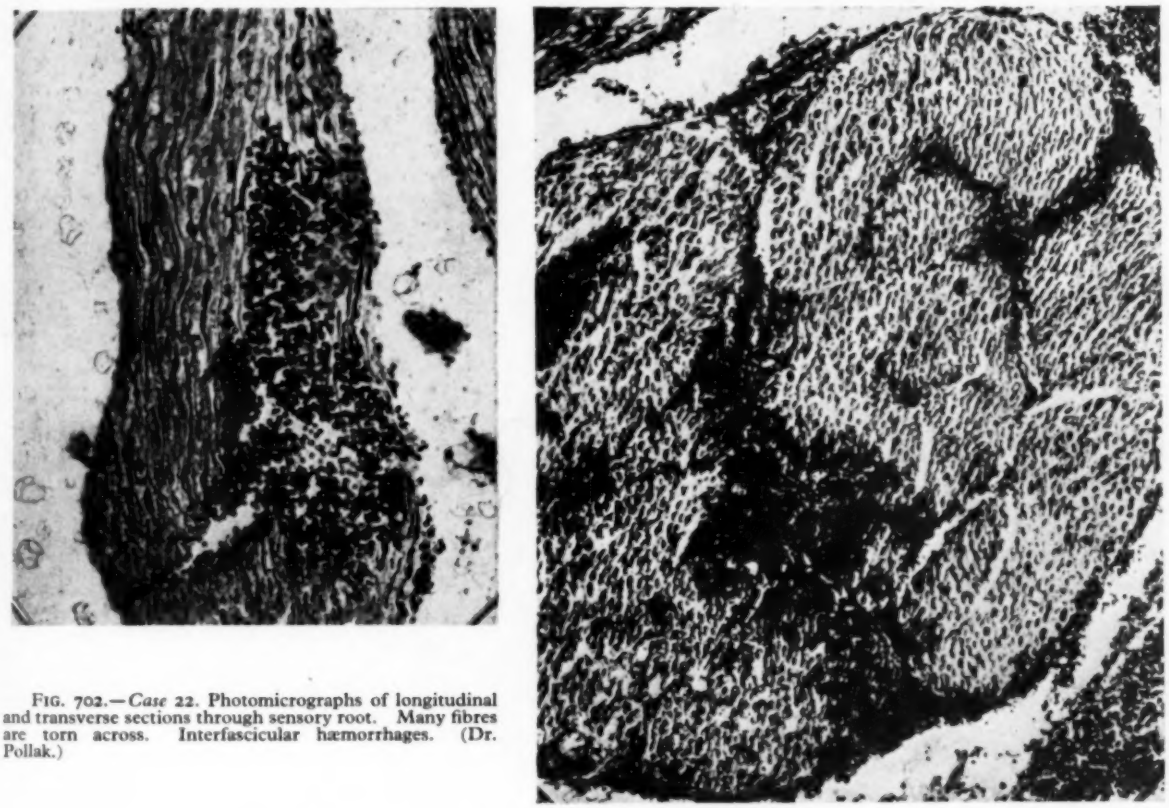

FIG. 702.—*Case* 22. Photomicrographs of longitudinal and transverse sections through sensory root. Many fibres are torn across. Interfascicular hæmorrhages. (Dr. Pollak.)

instantaneous deformities in the bones which produce the fracture line and the damage to nerves. Crush injuries with trigeminal nerve injuries of different patterns from the foregoing were described by both Riche (1892) and Lor (1897) (*see Table III*).

The patient bled from the right ear, and for one day it discharged cerebrospinal fluid. The right external rectus was slightly defective in power. On testing there was total loss of all forms of sensation in the right lower lip, gum, teeth, and tongue, with slight impairment of sensation in the upper lip and ala nasi. The right masticatory muscles were paralysed.

In the main, the injury must have fallen on the third division at the foramen ovale, with some slighter disturbance in the ganglionic structure to implicate the lower fibres of the second division. Radiographs of the skull showed a fracture line extending across the right middle fossa towards the petrous tip; no doubt it crossed the midline through the sphenoid to cause the ocular disturbance on the left side. The lower lip and tongue were still hypæsthetic 5 years later.

Case 24.—Mrs. A. P., aged 30, was transferred to the Manchester Royal Infirmary after primary treatment in another hospital March 3, 1952. She had had a head injury 2 weeks previously in the overturning of a motor-car in the course of some automobile trials. She was unconscious for only a brief period, but bled from both ears. On admission here she was found to have diplopia from left abducens weakness and numbness in the left half of the tongue and lower lip with slight weakness of the masticatory muscles on that side. She had mentioned her numbness in the first hospital, but it had been disregarded. On testing there was no doubt of the reality of the hypo-æsthesia to cotton-wool, prick, and temperature in the distribution of the third trigeminal division. The anæsthesia was not dense, nevertheless it was unmistakably a sign of contusion of the mandibular division. Radiographs were negative. Three months after the injury all signs of the nervous damage had disappeared, including the abducens weakness.

Comment.—No doubt in this case a basal fracture was present even though it could not be picked out by X-rays. The nerve lesion must have been at the level of the foramen ovale, since the numbness in the tongue as well as in the lower lip and the weakness of the motor fifth spoke clearly for a lesion at this high point. Traumatic weakness of the masticators was described specifically for the first time by Gardiner (1938) as a sign of nerve injury in head injuries. He had observed 3 cases, 2 with signs of involvement not of the third division but of the infra-orbital nerves, and in the third case he spoke of numbness of the cheek. These must have been independent lesions. That Gardiner's cases had only mild neural contusions like the patient just described was certified by the quick recovery of the nervous lesions.

Case 25.—**Canadian Army case. Motor-cycle accident, fractures frontal and sphenoid bones. Blind left eye. Injury to first and second trigeminal divisions.**

Pte. P. A. (H.87946) motor-cycle crash accident Dec. 4, 1944, France. Unconscious for 24 hours, then found to be blind in left eye; fundus oculi normal.

Corneal sensation absent. Total numbness whole territory of left second division, frozen feeling in teeth, hypo-æsthesia left forehead. The latter diminished in extent rapidly, indicating that only a few fibres in the first trigeminal division had been injured. External ocular movements normal. X-ray showed fractures of left frontal bone, left greater and lesser wings of sphenoid, left maxilla, and left malar bones. The fractures entered the left optic canal, left frontal sinuses, and maxillary antrum. One month later the numbness was diminishing in density. The exact site of the injury, whether a partial one in the upper and anterior end of the ganglion or whether lacerating the 1st and 2nd division separately, cannot be known. But whichever it was it must have been so close to the ganglion as to make the difference unimportant.

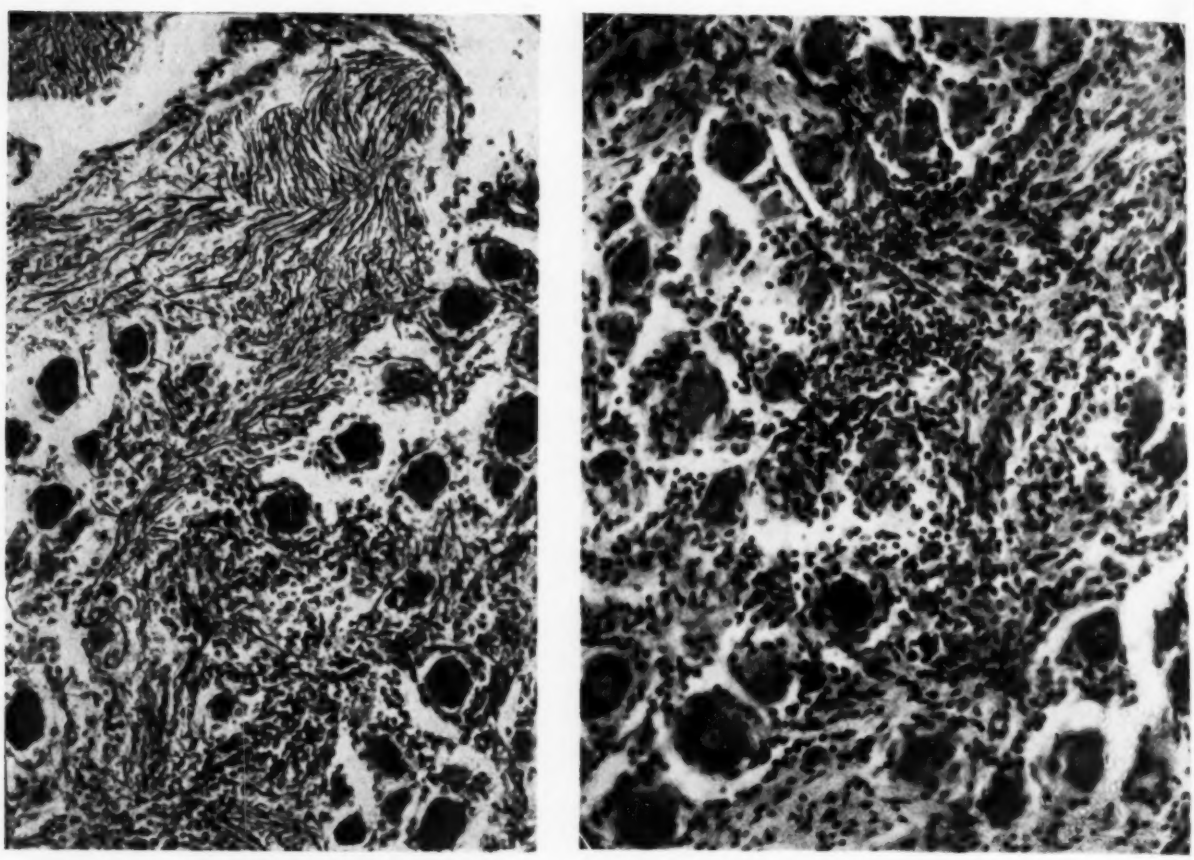

FIG. 703.—*Case* 22. Photomicrographs of Gasserian ganglion showing infiltration with blood, degenerative changes in ganglion cells and in nerve fibrils. (Dr. Pollak.)

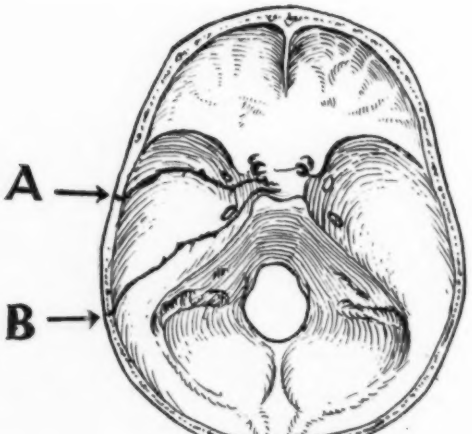

FIG. 704.—A, Anterior, and B, posterior fracture lines in middle fossa (*after Duret*).

Case 26.—**Head injury, fracture into middle fossa. Injury to second division at foramen rotundum.**

R. W. J. was injured in a motor accident, Dec. 16, 1939, when he was flung out of a car. He was rendered temporarily unconscious and bled from the left nostril. There was a left temporal hæmatoma and some ecchymosis into the orbit. Radiographs showed a fracture line running from the left anterior temporal region down into the middle fossa, which it crossed to reach the foramen rotundum. The day after the injury it was found that the left upper lip, cheek, gum, and the whole hard and soft palate except its edge were numb but not densely so. Evidently there had been a severe maxillary division contusion with laceration of some of the fibres in such a manner as to interfere with regeneration because sensation was still impaired, localization being defective a year later; no neuralgic pain occurred. For some 3 or 4 years sensation was slightly impaired in a small patch between the malar bone and lower lid. In this case the fracture line was the rarer anterior variety (*see Fig.* 704) described by Duret (1919).

COMMENT ON BLUNT GANGLIONIC INJURIES

Scrutiny of the literature has brought to light only another 25 cases since Wilbrand and Saenger's 1901 aggregation. They had no personal cases to add to those which they had found. The new cases discovered by the present writers, including three or four which Wilbrand and Saenger missed, are presented in *Table III*. As might have been expected, all the patients but two were males; in the present series only one was a female. Most of the injuries in the recorded cases were severe, but only occasionally did the patient remain unconscious as long as two or three weeks. Since it is necessary that the patient should be able to co-operate in some measure in order that the presence of trigeminal injury can be verified and the anæsthetic outline plotted, the patient's survival is a necessary requirement. A defective corneal reflex, even if unilateral, would not be enough to establish such a lesion in coma, since it would be statistically more probable that a seventh-nerve injury was the cause. Systematic searches at post-mortem might sometimes disclose a torn root such as was found in *Case* 22 here. In that case the patient had had short periods of consciousness before his death on the fourth day, periods which enabled the complete right-sided trigeminal anæsthesia to be discovered. There have been very few necropsies amongst the trigeminal injuries reported in the literature and none of them is well enough documented to be of real service. Histological pictures such as *Figs.* 702, 703 have not previously been published. In the post-mortem report of Bérard (1841), whose patient shot himself in the ear and died 10 days later, the ganglion was said to be soft and friable but the divisions healthy; in Hirschfeld's patient (1859), who had an arterio-venous cavernous fistula, the nerve was said to be compressed by clot; and in Riche's case (1892) the ganglion was hard and red at death 36 days after a crushing injury. Bonnet commented on the worthlessness of the existent post-mortem material in 1904 and matters are no better now. The reason for this has, in effect, already been given—namely, that a trigeminal injury is not likely to be sought for unless its presence has been recognized before death. Yet some pathologists must surely have seen these injuries without reporting them. That blood within the sleeve of cerebrospinal fluid surrounding the trigeminal root is not uncommon we know from our own observations, but it probably does not have recognizable clinical consequences. Paralysis of other nerves was as common in the present series as in the previously recorded cases; the 6th nerve was that most frequently affected (5 cases), the 7th next (4 times), whilst all three oculomotor nerves, 3, 4, 6, were injured on 3 occasions with temporary ophthalmoplegia. Monaural deafness was present in 2 subjects. Coincident injury is to be expected when the trigeminal nerve is damaged because of its close liaison with other nerves, especially those in the lateral wall of the cavernous sinus. This remark leads us on to some speculations on the mechanism of the nervous injury.

Table III.—BLUNT HEAD INJURIES
(25 *Cases*)

Author	*Trigeminal Divisions*			*Other Cranial Nerves*	*Cause*
	First	*Second*	*Third*		
Hirschfeld (1859)	+	o	o	o	Crush
Cassoulet (1869)	+	+	+	3 4 6	Fall on forehead
Delens (1870)	+	o	o	3	Fall on nose
Cras (1873)	+	+	+	6	Fall
Cathala (1875)	+	+	+	o	Fell 28 ft.
Cairon (1890)	o	+	o	7	Struck on L. temple
Despeignes and Murer (1890)	+	o	o	2 3 4 6	Fell from cart
Eaton (1891)	+	+	o	6 R. and L.	Fall
Guedes de Mello (1893)	+	o	o	2 3 6	Blow on forehead
Riche (1892)	+	+	o	6 7	Head crushed
Lor (1897)	+	+	+	2 3 6	Head crushed
Lapersonne, de (1902)	o	+	o	3 4 6	Fall from carriage
Dunn (von Bergmann) (1904)	+	+	+	6 7	—
Krönlein (von Bergmann) (1904)	+	+	o	6 R. and L.	—
Sonnenberg (von Bergmann) (1904)	+	+	o	6	—
Bonnet (1904)	+	o	o	3	Fell from bicycle
Bargy (1920)	+	o	o	2 3 4 6	Clubbed by robber
Terrien (1922)	+	o	o	3 4 6	Violent blow, eyebrow
Roger and others (1922)	+	+	+	3 7	Fell 12 ft. on L. temple
Rollet and Colrat (1927)	+	o	o	3 4 6 (hemiparetic)	Struck on R. eyebrow by iron bar
Gardiner (1938)	o	+	+ M	o	Motor collision
	o	+	+ M	o	Bicycle accident
	o	+	+ M	o	Fall
Russell and Schiller (1949)	+	+	+	6 7 (bilateral)	Crush
	+	o	o	2 3 4 6	Crush

Ever since 1844 when Aran announced that the vast majority of basal fractures were the continuation of fissures which commenced on cranial walls and ran down into the nearest basal fossa, the way was open to a more realistic appraisal of these injuries than had before been possible. Von Wahl (1883) added the theory of the bursting of the irregularly strong sphere which the skull is and Messerer (1880) his law that lines of fracture tended so far as is possible to be in the same direction as the force ("Querdruck, Querbruch; Längedruck, Längebruch") which produced them. The French further elaborated the mechanics of the lines of fracture in relation to the buttresses discernible in the skull's architecture and explained fractures coexistent but unrelated to the original fracture line, such as those of the orbital roofs. They interested themselves particularly in fractures of the petrous bones. The rarest of these is the vertical, transverse fracture cutting across from behind forwards through

the internal auditory meatus leading to nerve deafness, labyrinthine destruction, and facial palsy. In the majority of cases the fracture line is not transverse but parallel to the petrous axis and on its anterior surface. After descending from the cranial wall it crosses the bony external auditory meatus or tegmen tympani, proceeding medially along the line of the petrosal nerves, where it may catch the genu of the facial nerve, and ends either in the foramen lacerum

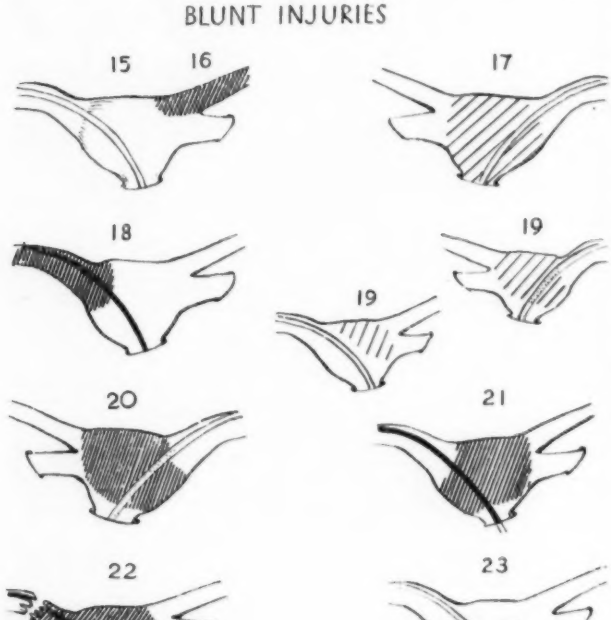

FIG. 705.—Diagram of estimated extent of ganglion injury in blunt head injuries reported here. Motor branch black when injured. Numbers refer to cases in text.

medium or crosses in the severest injuries the sphenoid to skirt back along the opposite petrous bone or else proceeds towards the opposite orbit according to the main direction of the force (*see Fig.* 701). In its medial traject it runs beneath the Gasserian ganglion. Only rarely does it enter the foramen ovale. Rawling (1912) saw this happen only once in his examination of 300 specimens. Although it is beside the present point, it might be mentioned that in the majority of middle-fossa fractures (for that is what these axial fractures of the petrous are commonly called) a striking feature is the dissociation of facial nerve damage from that of the auditory nerve. The deafness in such injuries is almost always of middle-ear type and not a true nerve deafness. The line of this fracture might well injure the Gasserian ganglion except that the fissure is usually fading out as it reaches the ganglion's shallow depression near the petrous apex. It is likely that the transient facial numbness, of which one or two examples have been given above, have been due to hæmorrhage or a momentary slight contusion from below as the fracture line parts. A more important injury in its neurological consequences is the fracture of the petrous apex. The medial end of this bone articulates lightly with the basisphenoid to which it is attached by the petro-basilar ligament, and is much its weakest part because there it is hollowed out by the pharyngo-tympanic (Eustachian) tube, the canal for the stapedius, and by the carotid canal. Severe injuries falling on the posterior third of the skull, and especially those on the mastoid, drive the petrous bone against the strong basilar process and produce a crush fracture of its apex (the "Knickungsbruch" of the Germans). Sometimes a scale of bone is detached which may cut the trigeminal root or ganglion or the internal carotid artery, as had happened in the two well-illustrated necropsies of Delens in his important monograph (1870) on carotico-cavernous aneurysms. In *Fig.* 701 the fracture of the petrous tip can easily be distinguished. Russell and Schiller (1949) in their experiments crushed skulls in the post-mortem room and observed the curious movement of the petrous bone that occurs, a backward rotation in which the petrous tip, a fragment of which often breaks off, moves more than the rest of the bone. As a result, the foramen lacerum medium opens up exposing the carotid artery, the displacement being

FIG. 706.—Schema of injury to petrous tip and widening of foramen lacerum in crush fractures (*courtesy of R. Russell and F. Schiller*).

one favourable to trigeminal root or ganglion rupture. Russell and Schiller illustrated this well in *Fig.* 706, reproduced here by their courtesy. The petrous seems to tear away along its anterior border from the floor of the middle fossa. These studies confirm those of Félizet and others who, further, had already demonstrated that this same sort of petrosal behaviour resulted from powerful forces applied to the mastoid and posterior third of the skull—as in violent falls.

The French experimenters came to regard the petrous bone almost as free or as a bone inarticulated except at its mastoid end; and though this seems a very improbable conception, experiment has proved that the petrous actually behaves in this unexpected way when great force is applied to the skull, whether that force be a blow on the 'free' head or a squeeze. Injury by comminuted bone fragments may not be the only way in which the ganglion is seriously damaged, torques and stretches of the dural coverings of the cavum Meckelii, internal stresses within the ganglion itself, and tension of such structures as Gruber's ligament might all be the causes of injury. The ganglion is a fixed structure tied down by its dural sheath and may be cut into by the lifting sharp bony edge of a fracture line. Alternatively the fixing of the ganglion and the mobility of its root suggests that one might be torn from the other in a violent distortion of relationships. However, the probabilities are that the most complete and permanent injuries are the consequences of crushes or displacements of the bone of the petrous tip at the moment of greatest distortion of the cranial capsule. In *Case* 22 there was not only a torn root but hæmorrhage into the stroma of the ganglion itself. Association of an abducens palsy with a trigeminal is readily understood, since the sixth nerve skirts close to the petrous apex, tunnelling the petrobasilar ligament in Dorello's canal (*see*, for instance, Vail [1922] on the anatomy of this part of the nerve's course). The companion injuries of the other oculomotor nerves as well as of the facial can be understood from the severe basal injury depicted above.

Concomitant Arterial Injury.—The fact that injuries to the Gasserian ganglion, whether by missile or blunt trauma, have been so often associated with lesions of the 3rd, 4th, and 6th nerves reminds us of the relationship of these nerves to the vascular components of that great neurovascular sheath, the cavernous sinus. Injury to the venous part might well pass unrecognized, but with the carotid artery the signs are unequivocal. C. H. Sattler (1920), in his monograph on pulsating exophthalmos, found 34 cases caused by gunshot wounds and a further 27 by punctures and stabs through the cheek, orbit, or temple. Only 15 of these 61 cases were associated with trigeminal injury. A notably good example was Braunschwig's (1905); in several of the others the evidence of trigeminal injury was slight and it is not clear whether it was due to the original injury or a later development from the aneurysm. Most often it is a secondary development. It is noteworthy that Sattler's statistics show the proportion of trigeminal lesions to be roughly the same whether the arteriovenous fistula was of traumatic or spontaneous origin. There were 15 examples out of 139 of the former and 6 out of 55 of the latter type, roughly 11·6 and 10·9 per cent respectively, suggesting that the aneurysm itself was the usual cause of the trigeminal numbness in both varieties. In our 26 carotico-cavernous aneurysms only 1 was caused by a penetrating wound, a stab wound through the orbit, and in this case the trigeminal was not injured. However, in 1 case reported now (*Case* 19), a crush fracture, there is no doubt that the trigeminal injuries occurred at the same time as the arterial. With spontaneous saccular aneurysms lesions of the trigeminal nerve are common (Jefferson, 1938) and we have 1 case of traumatic fistulous aneurysm which was converted later into a saccular aneurysm. Trigeminal numbness only developed in the second or saccular phase. In summary, we can say from our own experience that concurrent injury to the artery and trigeminal and other nerves in the cavernous sinus can occur, but that the combination is rare. Battle wounds of the cavernous sinus and the enclosed carotid artery must usually be quickly fatal and do not come under observation; the surprise is that any have recovered, but so it is.

Lastly, in support of what has been said just now about shearing strains as opposed to fracture lines as causal agencies the number of proven cases of basal fracture in carotico-cavernous fistulæ is small. It is true that the total number of traumatic fistulæ that have come to necropsy is less than 30 (de Schweinitz and Holloway, 1908; Sattler, 1920; Dandy, 1937), and most of these lack detail. Exceptions were the beautiful drawings from post-mortem dissections in Delen's thesis. They have already been mentioned and were well reproduced recently by Hamby (1952). The finer points of bony damage are almost impossible to demonstrate convincingly in the living subject even with good basal projections with X-rays, so translucent is the petrous tip.

If the ganglion is to some extent a fixed structure its issuing divisions are even more so, since they traverse foramina. In *Cases* 25 and 26 the injury resulted from the anterior or rarer type of middle fossa fracture and was divisional. In one, the fracture line was clearly traceable to the foramen rotundum, in the other the third division was the chief sufferer but ganglion cells must have been lost, too, because of the persistence of the numbness. Judged by normal surgical experience, divisional injuries or sections recover within the year. Absence of sensory recovery is therefore a sign of destructive ganglionic contusion.

There are some other forms of isolated trigeminal injury distinct from the ganglionic just described that merit special comment.

INJURIES OF THE NASOCILIARY NERVE
(6 *Cases*)

There are 6 examples of this injury in the present series. All were the result of severe compound fractures of the frontal bone in traffic accidents, with extensive comminution of the frontal and ethmoidal sinuses. The anæsthesia of the nose tip in 4 cases and of the cornea in 1 case was not discovered until the patients were convalescent. In 2 cases the nose tip was numb on both sides. In 5 of the patients surgical procedures were carried out; these entailed the removal of the fractured orbital roofs far back and the exenteration of the ethmoidal air cells from above. The numbness was not mentioned by the patients, although it had been observed by them, because it seemed to be of trifling importance, but it is interesting anatomically. The nasociliary nerve splits in the posterior part of the orbit into its two final divisions (*see Fig.* 707). In the one patient who had isolated numbness of the cornea the ciliary nerves alone must have been contused just after this point. The case has already been described by Schorstein (*Case* 3, 1943). It may be compared with that of

Felix Lagrange (1918) to which allusion has earlier been made. Lagrange's appears to be the first case of isolated ciliary injury mentioned in the literature; this seems to be the second. The clinical facts are plain—a local numbness of the cornea and globus oculi without anæsthesia of the upper lid or forehead.

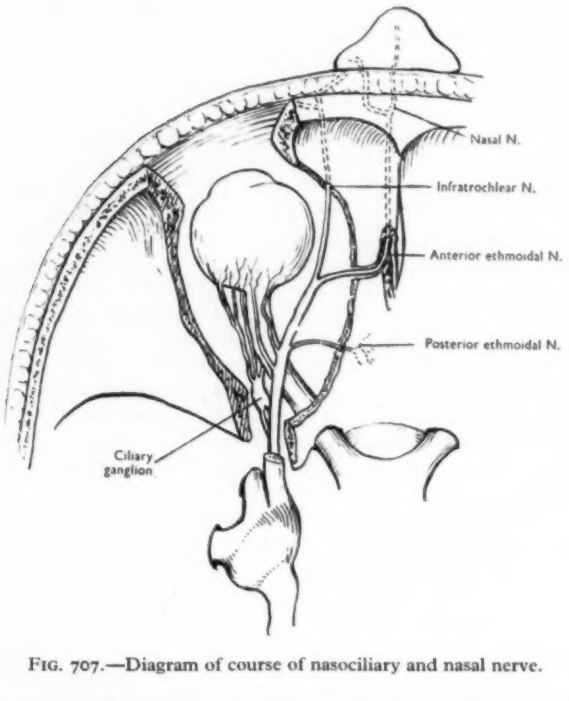

FIG. 707.—Diagram of course of nasociliary and nasal nerve.

It is a striking and rare event. It may be contrasted with the numbness of the whole face except the cornea in *Case* 28 below.

As for numbness of the tip of the nose and ala nasi the exclusive cutaneous supply is very variable. The nasal nerve leaves the orbit, having already lost the ciliary fibres, and turns medially to enter the anterior ethmoidal foramen in company with the artery of the same name (*Fig.* 707). The vessel and nerve with it may be divided at this point in radical operations on comminuted fractures of the base of the anterior fossa. That the nerve may be damaged by the fracture itself is evidenced by one of our cases where no operation was done yet the nose tip was numb. In another the injury might have been done at operation when the anterior ethmoidal artery was electrically coagulated. The nerve proceeds through the ethmoids to enter the roof of the nose and to course down to supply the septum, whereas its other terminal branch ends superficially between the junction of the nasal bone and the cartilage of ala nasi. It supplies the skin over the latter. The overlap from the medially directed branches of the infra-orbital nerve which sends filaments to supply the nose from the level of the inner canthus down to the cartilage and over it makes the nasal nerve's exclusive supply so small that it is difficult to assess. It is chiefly the rim of the ala on its medial two-thirds and a piece of skin 3·0–4·0 mm. above it (*Fig.* 708). Sensation may be altered over the whole ala and one side of the nose tip, but a pin is usually recognized and a variable proportion of the lightest touches. The inexclusiveness of this supply is attested by observation on other cases. We have mentioned that the nerve is often cut in operations on the ethmoid cells through the os planum or when the anterior ethmoidal artery is ligatured for dangerous epistaxis. We have examined several patients after operations of these sorts and have not been able to establish consistent results. Several patients have denied the least anæsthesia in the nose tip, though the nerve had unquestionably been sacrificed. However, when numbness is present it is a useful clinical sign of anterior fossa fracture.

INJURIES TO THE SECOND DIVISION
(32 *Cases*)

This is, of all subdivisions of the trigeminal injury, much the most common. First described by Sir Charles Bell (1830), and next by Henry Lee of St. George's Hospital (1852), a pathological specimen showing the nerve completely divided was presented by Dubreuil in 1870. Bell's example, reported to him by an Army surgeon, J. J. Russell, during the Napoleonic Wars, concerned an officer who fell downstairs in the dark whilst on duty in Portugal, striking the left side of the face against the stone flags. He complained, said Russell, of "numbness of the left side of the face extending from just below

FIG. 708.—Anæsthesia caused by left nasal nerve injury and right superior maxillary nerve including 3 teeth, gum, and small area of palate; average distribution.

the orbit, along the ala nasi to the tip of the nose and to the upper lip exactly as far as the centre of its depression, corresponding precisely with the distribution of the facial division of the second branch of the fifth pair of nerves". It was a good example of Bell's recent discovery of the entirely sensory nature of the trigeminal in contrast with the facial nerve.

It has just been said that infra-orbital nerve injury is a common sequel to head injury and so, in our experience, it has been in either sex, no doubt because we have looked most carefully for it. Others have not found it so common. Thus Friedman and Meritt (1944), in a study of 430 acute head injuries from the Boston City Hospital, found it injured only once. Of the cranial nerves, bilateral olfactory nerve

damage was the commonest (11 cases) whilst the facial came next with 7 and the abducens next after that with 2 examples. The frequency of olfactory nerve injury had already been well brought out in Leigh's paper (1943).

The injury may result from a fall on to a hard floor if the impact is neatly on the malar eminence, more easily by a fall on to a projection, but it can come also from a heavy blow by a fist or from a knee or a foot at football—it can happen in a dozen ways. Surgeons interested in facial reparative surgery must discover infra-orbital anæsthesia very often, but they are apt not to mention it. Ivy and Curtis (1945) reported it as having been present in 9 out of 10 cases of malar-maxillary fractures; it was there in all Leegard's cases (1939), and in 7 out of 14 of those very well reported by Ungley and Suggitt (1944). The matter is of more importance than some might imagine, for it can be the best early and easily obtained clinical evidence that a fracture is present. The great majority of the cases seen by us have been referred because the cheek and upper lips were numb, not because he or she was thought to have a fracture. This is really the wrong way of it. Most were seen at an interval of several weeks or months after the injury when the bone displacements had become so fixed that re-alinement, if desirable, was difficult to achieve. A special point must be made of the presence of anæsthesia of the cheek and upper lip in these facial injuries, because within an hour or so swelling of the face usually obliterates the deformity produced by the infraction of the malar bone. The numbness remains as a sure sign that a fracture is present, a fracture that requires specially angled views to make it clearly apparent. Recognition of the fracture is most desirable at a stage when reduction is simpler.

Mechanism of Injury.—The exit of the infra-orbital nerve into the cheek shares with the globus oculi its immunity from direct injury during blows from a reasonably flat surface by reason of the peri-orbital bony crescent. The malar and nasal bones joined by the supra-orbital bar are an efficient protection except when the force is so great as to smash down the protective eminences; one or the other of the bony components then gives way, usually at several places, but a common fracture line runs through the infra-orbital canal. The mechanism of the underlying fractures caused by direct violence was worked out most carefully by R. Le Fort (1901) on the basis of numerous experiments. His conclusions have been generally accepted, even though later writers embellished his findings. Le Fort's fracture lines are three (*Fig.* 709). The inferior, Guérin's fracture, splits the lowermost part of the maxillæ from side to side off the facial superstructure. Except that dental and palatal anæsthesia might ensue on a very complete separation this fracture does not concern us. Nor does the superior which fractures the nasal bones and runs from side to side as if to separate face from calvarial capsule. It is the middle fracture line which interests us neurologically. It runs a course (*Fig.* 709) through the inferior orbital canal or infra-orbital foramen and hence most often injures the infra-orbital nerve, in so doing drawing attention to its presence by numbness of the upper lip. The maxillary-zygomatic component is displaced in the severe fracture which may break through the pterygoid process. These are the injuries produced by such mechanisms as were mentioned just now. They are common in motor-cycle and motor-car collisions and in falls. In the admirable drawings of these fractures in Erich and Austin's book (1944) all possible lines of fracture

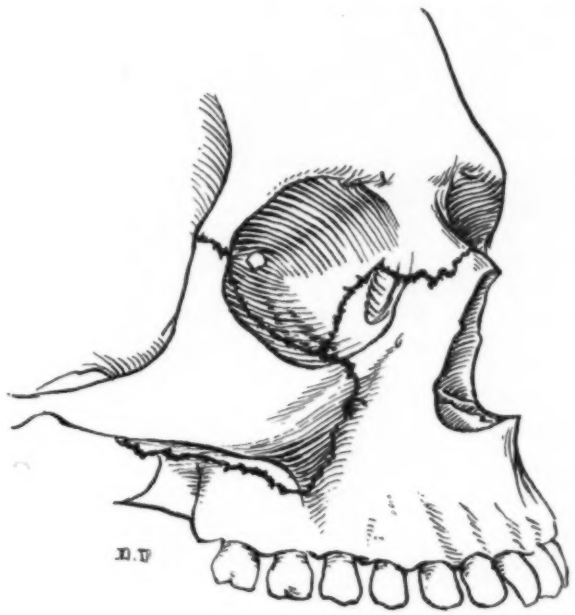

FIG. 709.—Lines of maxillary fracture (Le Fort).

and degrees of comminution are illustrated. There are too many subvarieties to allow of their reproduction here.

In none of these injuries save the most extensive imaginable, when the face is practically separated from the skull, could the maxillary nerve be torn through as far back as the foramen rotundum. Hence the posterior palatine group and Meckel's ganglion usually escape, even in bad injuries. It results that in the vast majority of cases fractures of either the zygomatico-maxillary or naso-ethmoid bone-complexes produce a maxillary-nerve injury that results in anæsthesia only in the anterior part of the gum, a local portion only of the adjacent palate, and the upper lip and cheek.

Site of Injury to the Nerve.—The area of cutaneous supply of the maxillary division is well known. We have no comment to make. The important point in clinical neurology is the estimate of the point at which the nerve has been damaged. The solution will be found in the extent to which the teeth, gums, and in particular the palate have been made insensitive (*see Fig.* 711). The nerve-supply of these structures is rich; Wood Jones (1939) showed that the accepted accounts of the innervation of teeth and gums are wrong in many respects. After a critical survey of the literature he concluded that the description did not tally with his dissections. Thus, of the three groups of dental nerves currently described (anterior, middle, and posterior), the middle were usually absent and the supply of the anterior called for a new description. The anterior

superior dental nerve leaves the main maxillary trunk, according to Wood Jones, much further back than is supposed, at a site 15 mm. behind the infra-orbital foramen. It was not uncommon to find the nerve separated from its parent trunk as far back as the extreme posterior end of the infra-orbital canal.

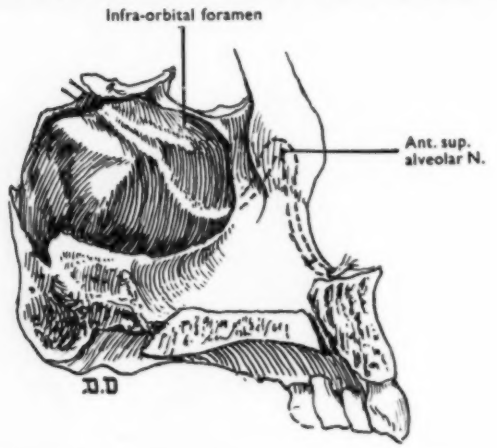

FIG. 710.—Course of left anterior superior alveolar nerve seen from antral aspect (*after Wood Jones*).

This would have the surgical result that pure local infraction of the infra-orbital foramen, whilst leading to numbness of a wide cutaneous area of the cheek, side of the nose, and upper lip, would not cause numbness of the ipsilateral incisors and canine. This dissociation in our experience was only encountered in 2 out of the 32 cases; but the fact that it happened at all is interesting. The inference might be that the injury habitually occurs deeply—say, at a point at least 15 mm. behind the point of emergence of the nerve in the cheek. That might sometimes be the case, but there is another explanation. Wood Jones found that the anterior superior dental nerve after leaving the lateral surface of the infra-orbital nerve runs in a bony canal of its own, a canal that he called "canalis nervi alveolaris superioris" or "canalis sinuosus" (*see Fig.* 710). In this it sweeps away to arrive lateral to the infra-orbital canal, from which position it curves crescentically to cross so close below the infra-orbital foramen that a fracture here will almost certainly injure both nerves. After a course 5·5 cm. long, it terminates in a foramen on the inferior bony spur of the nasal septum (the foramen septale of Wood Jones). It can be concluded that any fracture line that runs through the anterior wall of the maxilla and infra-orbital canal cannot help but open the anterior superior dental canal and injure the contained nerve. Were it alone injured the upper incisors and gum would alone be numb. We have seen 2 such cases. One was this :—

Case 27.—**Severe head and facial injury, transient numbness of cheek, persistent anæsthesia of anterior superior alveolar nerve. Recovery of 3rd nerve palsy.**

D. S., a woman, aged 40, fell from a cycle Oct. 7, 1941, her left face struck the kerb-stone and she was stunned for several minutes. The left eye closed at once and remained shut for 6 weeks. The left cheek and anterior gum and teeth became numb at once. When first seen after 5 months the third nerve palsy had recovered except for residual weakness of the superior and inferior recti. Careful tests failed to reveal any residual cutaneous anæsthesia over the cheek, but the left lateral and medial upper incisors and the canine were numb to touch with a piece of paper and to gentle pressure with a pinhead. The surrounding gingival tissues were also numb to touch and pin-point. It seems that in this case the fracture line had led to a more complete anæsthesia of the alveolar nerve than of the larger infra-orbital portion. No numbness of the septum could be established; the turbinal was not tested.

Palatal Anæsthesia.—Anæsthesia of the hard palate is rare because the palate is supplied by the anterior and posterior palatine nerves and these emerge via the sphenopalatine ganglion dependent from the maxillary trunk very far back (*see Fig.* 711). Few fractures extend so completely through the substance of the upper jaw as to reach the sphenopalatine fossa at a high enough level to imperil the maxillary division. It requires an injury to this division either intracranially (as in *Cases* 8 and 26) or immediately distal to the foramen rotundum extracranially (as in *Cases* 10 and 12) to induce numbness in the palate. A very severe injury such as would loosen the maxilla from its deep attachments (and such injuries sometimes take place) would cause total second division anæsthesia, with numbness of the palate and all the teeth. We have no example; the mechanism in our cases with palatal anæsthesia was mainly missile injuries. It would be a wearisome

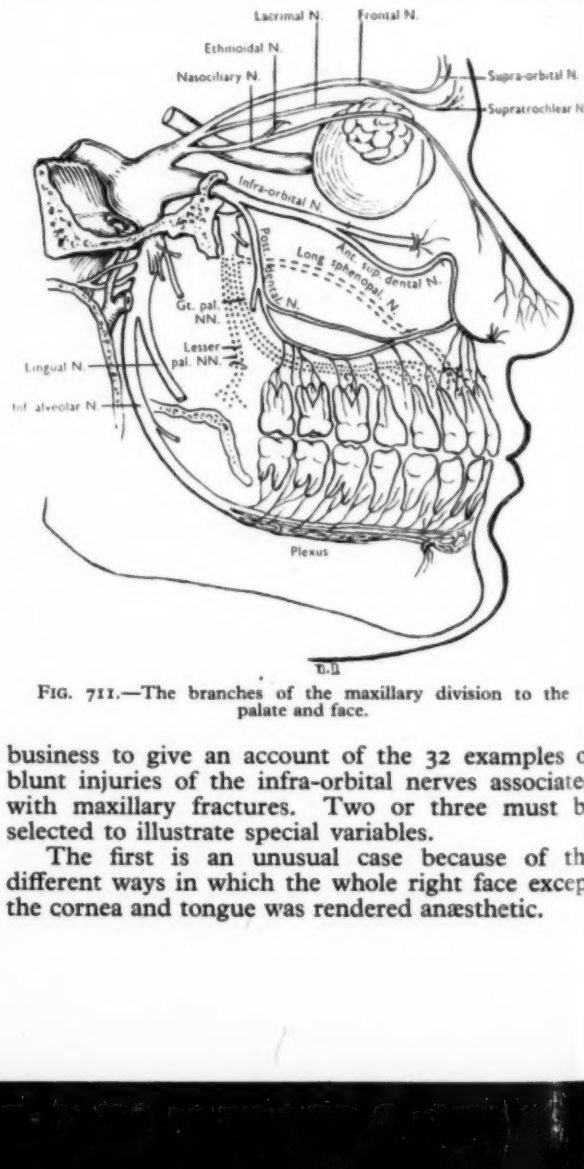

FIG. 711.—The branches of the maxillary division to the palate and face.

business to give an account of the 32 examples of blunt injuries of the infra-orbital nerves associated with maxillary fractures. Two or three must be selected to illustrate special variables.

The first is an unusual case because of the different ways in which the whole right face except the cornea and tongue was rendered anæsthetic.

Case 28.—**Severe head injury, fracture into frontal sinus, fractures of upper and lower jaws. Numbness of all three divisions, sparing the cornea, upper eyelid, tongue.**

P.R., aged 20, female, was injured in a motor-car accident in Germany on July 10, 1937. Her face was violently struck in the complete wreckage of the car and immediately swelled until she was barely recognizable. She was stunned but not unconscious. There was a cut over the right eyebrow, bleeding from nose and mouth, inability to open the mouth widely. She was treated conservatively and flown home three weeks later. The subcutaneous hæmatomas had subsided, but on the day of arrival the right eyelid swelled and closed the eye, with an elevation of temperature. Radiography: Dr. Twining reported: (1) a fracture line running downwards and backwards from the nasal process of the skull into the floor of the anterior fossa; (2) fracture through both walls of the frontal sinus and dislodgement of the crista galli, which was deflected to the right; (3) fractures of the nasal bones and of the right superior maxilla; (4) fracture of the right mandible through the wisdom tooth socket.

After consultation with Mr. Smalley the right frontal sinus was operated upon the same night, its broken anterior wall and floor being removed without chiselling. No gross collection of pus was present, staphylococci were grown from the bone removed. Recovery was uneventful. Trigeminal anæsthesia; with the exception of the cornea, upper lid, palate, molar teeth, and tongue, the whole of the right side of the face and mouth was numb. The forehead was anæsthetic from the wound in the eyebrow which had divided the supra-orbital nerve, the cheek and incisors were numb from injury to the infra-orbital trunk in the maxillary fracture, the lower lip and mandible anteriorly from the fracture of the lower jaw posteriorly in the horizontal ramus. This is an odd happening, the like of which has not been repeated, and is a classical example of the difference between peripheral injury and that occurring as deep as the foramina in the skull base.

Twelve years later the patient was still aware of a slight hypo-æsthesia in the lips on the right; she never held a cigarette in that side of the mouth. There was no pain; regeneration had occurred without any causalgic manifestations.

The next case presents a contrast with *Case* 27, for the teeth were not anæsthetic although the cheek was. The injury must have been a local one at the infra-orbital foramen, sparing the anterior superior alveolar nerve.

Case 29.—**Local contusion of infra-orbital nerve sparing alveolar nerve.**

Mrs. A. H., aged 33, was injured in a motor collision, April 30, 1940. She was thrown forwards, striking the right side of the face violently on the back of the front seat. She was stunned, but not unconscious. There was a cut in the conjunctiva which required suture. The right side of the face was generally swollen for some days by subcutaneous bleeding and the right nostril bled severely. As this subsided she became aware of numbness of the right upper lip, side of the nose, and cheek. There was diplopia on looking downwards. When seen a month later she was insensitive to cotton-wool and pin-prick in the area supplied by the infra-orbital nerve. Neither teeth nor gum were denervated; the palate was normal. No fracture could be felt or seen on radiography, but very probably a crack into the infra-orbital foramen was present. There was a droop of the right angle of the mouth from contusional palsy of some fibres of the seventh nerve. The patient was bothered by paræsthesiæ in the numb area and by the subjective feeling of the swelling and coldness which is the rule in anæsthetic areas.

Not infrequently the paræsthesiæ are very uncomfortable, but it is only rarely that resection of the nerve may have to be considered. It was carried out in only 1 case, a young soldier with a very severe facial injury that needed reposition and fixation of the left maxilla. Intracranial resection of the second division and a fractional cut of the estimated second-division fibres in the sensory root were carried out by R. A. Bailey with immediate relief but with relapse four months later. Another such case followed the same course. This leads on to the next section, a brief note on painful sequelæ to antral operations. Ungley and Suggitt (1944) deliberately divided a badly injured nerve in one of their fracture cases for fear of later neuralgic troubles.

Injuries at Operation.—Partial injuries to the infra-orbital nerve are by no means unknown in the course of operative procedures on the maxillary antrum. This seems to be especially the case with chronic infections where a curette or punch is used to remove thickened or polypoid mucosa. The walls of the infra-orbital canal are not always complete and are very thin in the middle and posterior part of its length. Both it and the anterior superior alveolar nerve make considerable saliences into the cavity of the antrum and the walls of their canals are paper-thin. An infective neuritis may occur by spread into the perineural sheath of connective tissue that surrounds the nerve and its vessels in the canal. For whatever reason, severe pain of an intractable character often accompanies antral infections; it may become worse after radical operation, and sometimes dramatically so. We do not intend to set out at length our experiences with these well-nigh incurable cases, nor are they included in the list of trigeminal injuries on which this paper is based, because it is often uncertain to what extent hypo-æsthesia is due to injury or alternatively to spread of infection from neighbouring structures. At least 4 cases might have been added in which the probability of injury was very great. One of these will be mentioned.

Case 30.—Miss A. M., aged 43, had suffered for some years from nasal catarrh with periodic swelling and throbbing pain in the left cheek. Several intranasal operations were performed without benefit. Finally because of her complaints of burning pain in the cheek and eye a radical operation was carried out at another hospital. Polypoid mucosa was removed and drainage instituted into the nose. On recovering from the anæsthetic the patient experienced violent pain in the left cheek and gum radiating widely. It was much worse than anything she had felt before and in addition the left cheek and lip felt numb and swollen. During the next few years after the antral condition had become stabilized and the infection apparently cured she continued to complain of severe pain. There was depression of sensibility to touch, pin, and temperature in the infra-orbital distribution. Several attempts to relieve this by surgical measures, including intracranial resection of the second division and anterior parts of the Gasserian ganglion, failed to stop her pains.

This case is typical of the bad results that may occur in certain individuals, although it is probable that in others similar nerve injuries recover without ill effects.

INJURIES OF THE MANDIBULAR NERVE
(8 *Cases*)

No study appears to have been made of injuries of the mandibular nerve, though the classical case reported by Bell (mentioned later) has been on record for over a century. The common causes are two: (1) Posterior fractures of the horizontal ramus of the mandible; (2) Tooth extractions.

1. Mandibular Fractures.—It is difficult for a fracture of the horizontal ramus not to run through a tooth socket, but surgeons to-day are more reluctant than once they were to lay down a rule as to the commonest site. The canine fossa used to be given as the usual place, and it seems that fractures do take place often thereabouts, though more often at the angle of the jaw (30·8 per cent and 44 per cent respectively—Ivy and Curtis, 1945). The inferior alveolar (mandibular) nerve emerges to supply the lower lip through the mental foramen, i.e., 1·0 cm. or so behind the canine fossa, and therefore in the common jaw fracture the nerve escapes truncal injury. Fractures located more posteriorly must damage the nerve enclosed in its canal, with consequent anæsthesia of the lower lip, distal gum, and teeth. Careful observations on the frequency of these nerve injuries in mandibular fractures are badly needed. Their effects are occasionally, but apparently only occasionally, very troublesome to the patient, as was seen in a case referred by Professor Wilkinson from the Turner Dental School in 1941.

Case 31.—**Bilateral mandibular fracture. Numbness of the whole lower lip and chin. Troublesome paræsthesiæ and pain.**

C. H., male, aged 57, fell from a height and fractured the mandible in March, 1940. The bone was broken through behind the last molar tooth on each side. There was immediate numbness of the lower lips and teeth. He was seen 7 months later, when he was complaining of pain at each mental eminence. It was a painful pricking sensation, with a subjective feeling of great weight. The lower lip felt as if it were greatly swollen and was always burning. He grew a beard to protect the chin from cold, but took it off when it did not succeed in its purpose. On testing sensation, cotton-wool was appreciated, but he failed to recognize pin-prick in the numb area in 80 per cent of trials, nor could pressure pain be evoked. The jaw was soundly healed.

However, Professor Wilkinson carried out open operation on 2 similar cases and opened the neural canal through the gum at the site of injury, dividing the nerve cleanly with relief of pain. Probably the same treatment should have been applied to our case, of which 3 more have been seen, but they do not merit detailed record since the syndrome is so obvious.

2. Tooth Extractions.—The first account of mandibular nerve injury by tooth extraction was given by Sir Charles Bell (1830). In this case "a very learned and ingenious gentleman" had a molar removed by an inexperienced hand. "On putting a tumbler to his lips, he said, 'Why have you given me a broken glass?' He found presently that the glass was entire, but that he had lost sensation of one half of his lower lip." Bell says that several years afterwards the anæsthesia remained unaltered and that particles of food were apt to adhere to the lips without the subject's knowledge. We have seen similar examples, but to dental surgeons they seem to be commonplace. The general impression is that they recover within a few weeks, but this is not the invariable rule. We have seen 1 bilateral case and 3 unilateral cases where the recovery was incomplete after the normal period required for regeneration. Such a failure is more impressive in the case of trigeminus, a nerve that exhibits astonishing propensities for regeneration, as the history of the treatment of trigeminal neuralgia so clearly demonstrates.

The inferior dental nerve passes along in its canal 2–3 mm. below the apices of the teeth, and it is almost impossible to reach or grasp it with extraction forceps. The mechanism of injury during extraction, Professor Wilkinson informs us, is well established (no literature on the subject has been discovered). It is due to pressure with the extraction forceps whilst they are being deeply settled into position. The cancellous tissue of the mandible is relatively malleable and can be crushed down without the use of extreme force into the inferior alveolar canal. Sometimes the same may happen if chisels and elevators are incautiously used in the deeper dissections required for the removal of impacted or unerupted wisdoms. Since it would appear that the roof of the canal is thrust down, the frequency of recovery must indicate that no permanent deformity is left behind—that it is a very temporary inbending. But the fact that permanent hypo-æsthesia or dense anæsthesia can sometimes occur suggests that a more lasting disturbance of the jaw architecture may, if rarely, be brought about. Damage by the traction of the individual radicular nerves on the main trunk does not seem to be an active cause of anæsthesia, though it is a theoretically possible cause of minor and transient sensory change. Very rarely the tooth roots incurve below the canal so that the nerve is enclosed; a similar state is brought about by hypercementosis of the roots. In such conditions lasting nerve damage necessarily follows extraction. There would seem to be considerable danger to the nerve in the operation of apicectomy of teeth behind the mental foramen, and it would seem that many experts avoid this region for that very reason.

SUMMARY

1. Sixty-six new cases of injury to the trigeminal nerve are reported, of which 16 were ganglionic lesions. Of the Gasserian injuries 7 were caused by penetrating G.S. Ws, 9 by blunt injuries.

2. Intracranial damage to the trigeminal divisions peripheral to the ganglion can occur in both types. It is rare.

3. The commonest injury (32 cases) is that of the infra-orbital nerve. The interpretation of numbness of the teeth and palate is discussed.

4. Injuries of the nasociliary nerves are infrequent (6 cases). Their relationship to fractures of the anterior fossa is described. Injury to the ciliary nerves alone occurred in 1 case.

5. Concurrent injuries of other cranial nerves are not common in the intracranial injuries.

6. The mechanism of injury to various parts of the trigeminal system, including root injuries, is considered, especially in relation to fractures of the tip of the petrous bone. Recovery of sensation is uncommon after the severer ganglion injuries,

especially in those due to gunshot wounds. Numbness persisting for years is almost the rule after such wounds. Painful paræsthesiæ may persist.

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THE PNEUMATIC-TYRE TORSION AVULSION INJURY

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In 1888 John Boyd Dunlop† re-invented the pneumatic tyre and, subsequently, the development of transport affected the environment of the whole civilized world. Perhaps it is true to say that such an advance never leaves the history of medicine untouched, and the increased incidence of road casualties is ample evidence in this instance. Here, we are concerned with a lesion directly associated with the pneumatic tyre, known as the ' pneumatic-tyre torsion avulsion injury ', or the ' pneumatic-tyre friction injury '. In this lesion, the skin of a limb is torn from its deeper structures by being trapped between the tyre of a vehicle and the road.

This communication concerns 50 cases suffering from this injury which were admitted to the Plastic Surgery Centre for Wales during the past four years. Forty (80 per cent) were children under sixteen years of age, and 10 (20 per cent) were adults. The vehicles which caused the injuries were buses in 29 cases (58 per cent), lorries in 17 cases (34 per cent), and cars in 4 cases (8 per cent). The site of the injury was most commonly the lower limb. In only 3 patients was the upper limb involved. No case was seen where the trunk alone was involved, but in 7 patients the lesion extended from the thigh to the pelvis. The most severely injured were those in whom the thigh was primarily involved, but with extensions to the leg and pelvis. All were of such severity as to require reconstructive surgery by skin-grafting or flap repair.

Three distinct groups are recognized :—

1. Thirty-three patients admitted within a few weeks of their accident are referred to as ' primary ' or ' delayed primary ' cases.

2. Seven patients presented with granulating areas after sloughs had separated are referred to as ' neglected cases '.

3. Ten patients with late deformities due to this lesion are referred to as ' late results ' of pneumatic-tyre avulsion injuries.

The pathology and treatment of these three groups differed considerably.

MECHANISM OF THE INJURY

The structures directly involved are the road, the limb, and the tyre, and these meet as a triangle of forces. The active part is taken by the tyre which depends for its momentum on the weight and speed of the vehicle and the application of brakes. The surfaces of the macadamized road and the rubber tyre are so constructed that their co-efficient of adhesion is very high, and they are solid and unyielding as compared with the softness of the limb. As the accident occurs, the solid road and tyre grip the more soft and yielding limb. The skin is drawn between their approximating forces and, at the same time, the bulky contents of the limb are forced ahead. This must necessitate disruption within the limb, which usually takes place at the level of the deep fascia. If the force continues, the skin must burst, laying open the contents of the limb to further damage and destruction.

PATHOLOGY

The extent of the lesion may vary widely from simple stripping of viable flaps to complete destruction of the limb requiring amputation. This paper has, however, been confined to those cases where there is tissue loss in a viable limb.

The findings in a primary case are best seen at operation without tourniquet. It is usual to find large flaps of obviously dead or necrotic skin with peripheral areas of doubtful viability. Under the skin is found a layer of disrupted fat with damaged and thrombosed vessels and collections of œdema fluid, with a high content of fat droplets and blood. In the plane of separation, there may be large collections of hæmatoma which are hidden and only found on exploration. If the flaps are not excised within a few days, fat necrosis occurs, fluid collections become foul-smelling, and gas formation takes place where there is pocketing. Infection is certain to develop in this most suitable medium, and may be accompanied by septicæmia with an extremely ill patient. Those flaps of doubtful viability always become gangrenous throughout.

The deep fascia may be intact without serious damage being done to it, but, more often, it is torn or may be completely disrupted. Scattered patches of adherent fat remain attached to the fascia.

Of the deeper tissues, the muscles are most liable to suffer serious damage. Various fascial planes may be laid open with muscle destruction. Frequently, muscle damage may be done without opening of fascial compartments. This can produce a tension œdema or tension hæmatoma, which, if it is allowed to grow, will cut off its own blood-supply and produce a condition comparable to Volkmann's ischæmia. This is a frequent sequel to crush injuries of limbs where such fascial compartments are not decompressed. When they are incised, a salmon-pink muscle will belly itself through the incision in the fascia at considerable tension, unless decompression is instituted within the first few hours of the injury.

Major vascular or nerve injuries are not a common accompaniment. Although the femoral artery may be exposed along its whole length, it is rarely damaged and heals over well with free-grafting. Division of the brachial artery has been found, on one occasion, beneath an intact but avulsed skin with hæmatoma

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† There is evidence that a cushion tyre of leather existed in the days of the Pharaohs. In 1845 Thompson, a Scotsman, invented a rubber pneumatic tyre, but it did not meet with the success of the solid variety which was first invented in 1846. In 1888 Dunlop, a Belfast veterinary surgeon, invented his pneumatic tyre for his son's tricycle. It was first manufactured for bicycles in Dublin.

formation. Injury to the sciatic nerve is not seen but the external popliteal may be damaged where it lies superficial.

Fractures are common where the bone is subcutaneous, but are rare where it lies deep in muscle. Fractures of the tibia are seen, and yet, in a large number of avulsion injuries involving the thigh, only very rarely is the femur fractured. Exposure of the knee-joint is occasionally found. Fracture of the pelvis may occur with laceration of the vagina, and be complicated by rupture of the bladder and rectum. Generally, however, fracture appears to be an uncommon complication.

Neglected avulsion injuries may be defined as those which have survived over-prolonged conservative measures. The sloughs have been allowed to become gangrenous and separate at a line of demarcation. The underlying tissues granulate and become chronically infected. Many of these are left for several months before any attempt at repair by skin grafting is carried out. In extensive cases the patient suffers from hypoproteinæmia, anæmia, and profound cachexia with all its consequences.

The late results of avulsion injuries are many and varied, but mostly they present with scar contractures. These scar contractures produce flexion or extension deformities of the region affected. Many of these late results are due to poor healing by scar epithelium, which is unstable, and frequently breaks down into an ulcer. A neoplasm developed in the site of one such lesion. These areas of unstable skin are frequently present over bony prominences.

MANAGEMENT

Emergency Treatment.—The immediate treatment of all wounds of trauma depends on the extent and kind of injury sustained. The control of excessive blood-loss and the care of the damaged tissues are the first line of defence in combating shock. The application of a tourniquet above the site of the injury is rarely practical in extensive avulsion injuries, and even if it were, one would hesitate to recommend it. A well-applied tourniquet may, in a short time, produce such ischæmia as to give rise to irreparable soft-tissue damage in an injured limb. A badly applied tourniquet will merely increase blood-loss by producing congestion.

To attempt to carry out an immediate exploration of the wound and apply hæmostats is again not a practical procedure. The nature of the bleeding is usually a general ooze from small arteries and veins; the tissues are heavily blood-stained, making important structures difficult to identify, and interference in a wound at this stage may well increase shock by the further trauma it produces.

Severe hæmorrhage from a large vessel is best controlled in an emergency by digital compression. The rapid onset of traumatic vascular spasm frequently seals off such vessels completely, but this should not be finally accepted. Secondary hæmorrhage from this may occur up to several weeks.

The application of suitable pressure dressings with immobilization and elevation of the limb is the most widely applicable and best method of emergency treatment of the severely injured limb. It serves the triple purpose of controlling hæmorrhage, resting the damaged tissues, and preventing infection. This temporary measure is carried out by applying a single layer of tulle gras, several layers of thick gamgee bound by crêpe bandages, and a light shell of plaster-of-Paris.

Intravenous transfusion of adequate amounts of blood or plasma is essential in the restoration of the severely injured patient. It is absolutely necessary to restore the blood-volume and the oxygen-carrying power of the circulation before embarking on surgery. Whole blood is, for this reason, preferred to plasma. Oxygen therapy should not be omitted in badly shocked patients, and few methods of treatment produce such dramatic results in reviving these casualties.

Operation has occasionally to be delayed for twelve to twenty-four hours while resuscitation is being carried out. During this time antibiotics are administered in large doses, as are also anti-tetanus and anti-gas-gangrene serums.

The co-operation of the anæsthetist concerned must be sought as early as possible. This will give him an opportunity of having a clinical knowledge of the patient, following the primary treatment and progress, and prescribing suitable sedation before operation. To have an anæsthetic carried out on such an ill patient by one who sees him for the first time in the theatre is to be deprecated.

Operation is performed at the earliest opportunity which is consistent with the patient's general condition as agreed between surgeon and anæsthetist. Light general anæsthesia is administered through an endotracheal airway. A tourniquet is rarely used except in a small, well-defined lesion. The wound is thoroughly cleaned and an excision of all gross, dead, and dirty, and devitalized tissues is carried out as for other varieties of trauma. The difficult question arises as to how much to excise of undermined flaps. If the flaps have become gangrenous throughout, and a line of demarcation has formed, the decision is easy. However, in many early cases, where the surface appears viable, but subcutaneous fat and vessels have been damaged, one is tempted to be conservative. This is a pitfall, as these flaps do not survive, and one cannot err on the side of wide excision. Previous writers on this subject suggest de-fatting these flaps and laying them back as full-thickness Wolfe grafts. This method may be used in a smaller, clean-cut lesion, where the skin is not severely damaged. It is not, however, a practical or advisable method in extensive cases.

Where there is damage to muscles, these must be explored individually. Tension is relieved by dividing fascial compartments along their full length and removing all tissues which are not viable.

The only satisfactory method of treating open compound fractures, where there are large areas of skin to be replaced, is by internal fixation. This is not a treatment of choice, but of necessity.

Repair of Defect.—The repair of the defect need not be carried out as an immediate procedure, and is frequently ill advised in extensive injuries. In fact, better results will be obtained by doing this as a secondary procedure one week later. By this time a natural hæmostasis will have taken place, and a clean, dry wound will present itself for grafting. In the meantime moderate pressure dressings are

FIG. 712.—*Case* 1. Primary avulsion injury—pre-operation.

FIG. 713.—*Case* 1. During operation.

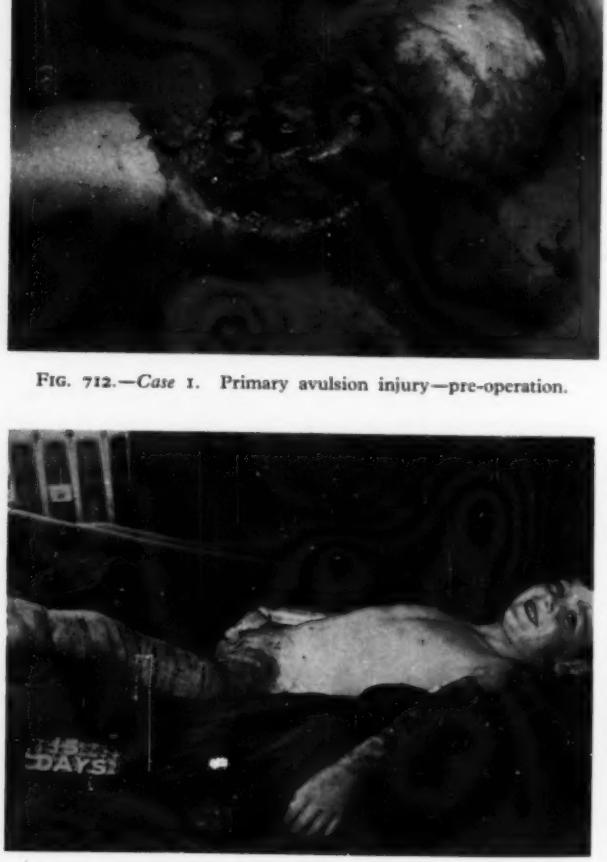

FIG. 714.—*Case* 1. Post-operation—full " take " of grafts.

FIG. 715.—*Case* 2. Delayed primary avulsion injury.

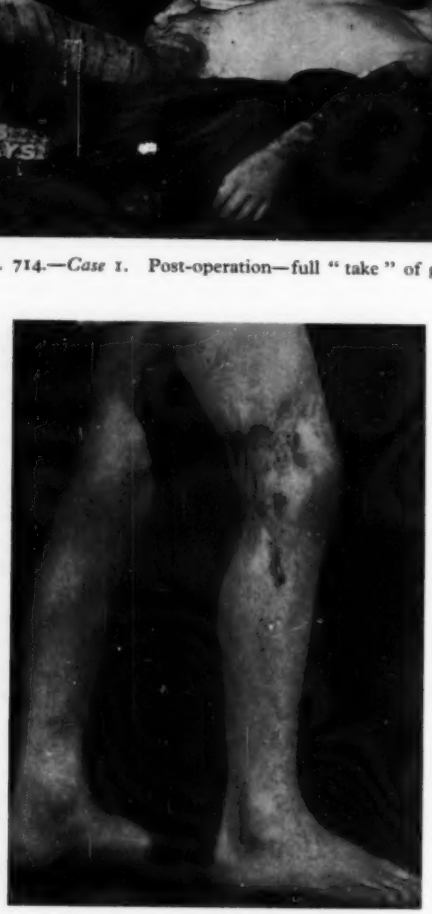

FIG. 716.—*Case* 4. Late result of avulsion injury—unstable contracture band.

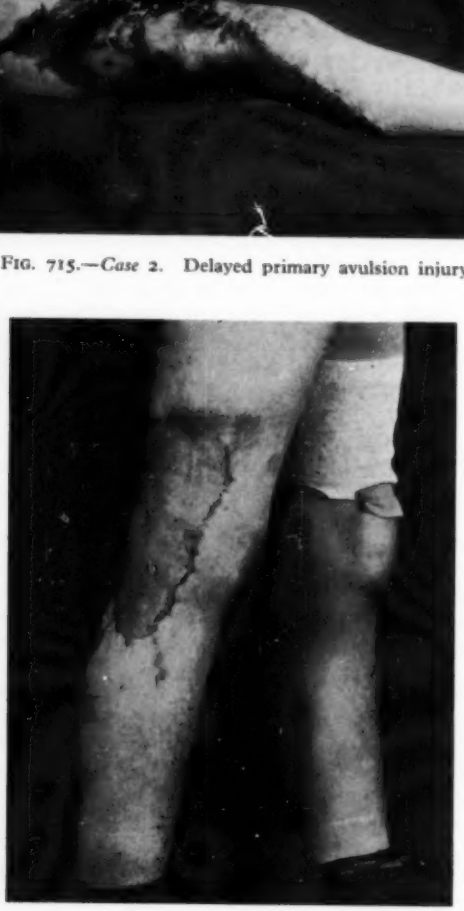

FIG. 717.—*Case* 4. Post-operation—dermatome graft.

applied with tulle gras, gamgee, and crêpe bandages, and a thin shell of plaster to immobilize the limb. During the subsequent three to four days it becomes obvious from the patient's general condition if the excision has been complete. The presence of a gangrenous skin-flap will show itself by signs of toxæmia, such as pyrexia, anorexia, pallor, pain, and odour locally.

In five to seven days the patient is taken to the theatre, having been prepared for grafting. On removal of the dressings a clean wound, suitable for free grafting, should be found if the excision has been complete. Adherent blood-clot or fibrin when present, is easily cleaned off. The wound is covered with a warm, moist dressing, while grafts are cut from a suitable site, preferably with an electric dermatome.

Treatment of the Neglected Lesion.—These patients are presented many weeks after the accident with varied granulating surfaces which are usually unsuitable for immediate surgery. Pre-operative preparation depends on the surface presented. If it is heavily infected, a culture of the organisms and their sensitivity to antibiotics gives an indication as to the local treatment necessary. A solution of 1 per cent streptomycin, applied over tulle gras, is effective in cleaning up most acute infections. Phenoxytol is recommended for *pyocyaneus*. Surfaces which are otherwise unclean are effectively treated with a 5 per cent Milton solution.

The primary object in the surgical treatment of these patients is to obtain healed surface by grafting on suitable granulations. If the granulations are not suitable they may be curretted from their fibrous base with a Howarth's raspatory, and grafting performed on this layer. Many of these patients will require further surgery on contracture bands which may have already formed. This is best done as set procedure on a healed lesion.

LATE RESULTS OF PNEUMATIC-TYRE AVULSION INJURIES

1. Contractures.—These develop at four sites —the groin, the back of the knee, the front of the ankle, and the adductor region. The first three produce flexion or extension deformities at the adjacent joint, with corresponding limitation of movement. They are relieved by dividing and excising the band. The defect so produced is often very large, and is usually repaired by a skin-graft, probably a dermatome graft, sutured into the defect.

Contractures of the adductor region may deform the rectum or vagina. A band running to the vulva produces ectropion of the labia and traction on the urethra and bladder. Relief of the contracture will allow these structures to return to their normal anatomy.

2. Unstable Surfaces which have healed by Scar Epithelium.—These are most frequently found over bony prominences. Repair is best performed by excision of the lesion and flap reconstruction. Such flaps may be local, such as bucket-handle flaps, cross-legged flaps, or tubed pedicle flaps.

3. The absence of subcutaneous tissues and fat produces a deformity in the outline of the limb which may be camouflaged by a light foam-rubber prosthesis (*see Figs.* 719, 720).

ILLUSTRATIVE CASES

Case 1.—**Primary case** (*Figs.* 712–714).

A boy aged 6 years was admitted two hours after having been run over by a bus. On admission his general condition was poor. He was severely shocked, with rapid pulse-rate, extreme pallor, and restlessness. An intravenous infusion of plasma had already been commenced and was shortly replaced by blood. There was no gross bleeding from the sites of his injury, which were the left lower limb and the left upper limb. No pulsation could be felt in his left radial artery. Owing to his general condition, exploration of his wounds could not be carried out for twenty-four hours. During this time he received four pints of blood.

At operation he was found to have extensive avulsion injuries to his left upper and left lower limbs. The full extent of the skin of his thigh was completely avulsed and badly traumatized. The underlying fascia and muscles were disrupted, with complete division of his adductor muscles. The knee-joint was widely opened and both collateral ligaments had been divided. Sciatic nerve and femoral artery were exposed, but intact. The full extent of the skin from the pelvis to below the knee was excised. A general débridement of the underlying fascia and muscle tissue was carried out. Pressure dressings and a shell of plaster-of-Paris were applied.

The skin of the left arm was intact but severely traumatized and avulsed from the underlying tissues. On exploration it was found that the brachial artery had been divided. This was ligated. Pressure dressings and plaster-of-Paris were again applied to the upper limb.

Skin-grafting was carried out one week later and a full take of the grafts was obtained. When these were consolidated he was rehabilitated, and he regained stability of his knee-joint within three months.

Case 2.—**Delayed primary case** (*Fig.* 715).

A girl aged 6 years was admitted with a history of having been run over by a bus five days before admission. Her general condition was poor, with a hæmoglobin of 30 per cent. Intravenous transfusion of blood was commenced and three days after admission, when her hæmoglobin had been brought up to 86 per cent, her injuries were explored. She was found to have an extensive area of gangrene of the right thigh, extending from the knee to the pelvic region. She had a fracture of her pelvis and her vagina was lacerated. The rectum was intact.

An excision of the sloughs was performed and the vagina repaired. A catheter was inserted into the bladder. Pressure dressings were applied and skin-grafting operations carried out on two subsequent occasions. She was discharged fully healed three months later.

Case 3.—**Neglected case.**

A girl aged 11 years was admitted seven months after having being run down by a bus. On examination she was found to have a granulating surface extending from the back of the knee onto the lateral surface of the leg and ending on the dorsum of the foot. A contracture band had already developed from the leg to the dorsum of the foot. A growth of *B. pyocyaneus* and *Staph. aureus* was found on culture.

After ten days' preparation of the granulating surfaces with Milton solution, the granulations were considered suitable for grafting. A full take of the grafts provided a healed surface.

One month later, the contracture band on the dorsum of the foot was divided and excised, and a graft sutured into the defect. She was discharged from hospital after three months, fully healed and with full movements of her ankle-joint.

Case 4.—**Late result of avulsion injury** (*Figs.* 716, 717).

A boy aged 9 years was admitted two years after having been run down by a lorry. On examination he

was found to have scar contracture bands of his popliteal fossa, which were unstable and were producing a flexion deformity on the knee-joint.

At operation the scar tissue was excised and a dermatome graft sutured into the defect. A full take of graft was obtained and he was discharged soundly healed four weeks later.

FIG. 718.—*Case* 5. Late result of avulsion injury—malignant change.

FIG. 719.—Late result of avulsion injury. A girl of 8 years with considerable deformity of her right leg due to loss of substance (fat).

Case 5.—**Epithelioma on the site of an old lesion** (*Fig.* 718).

A man aged 35 was admitted with a history of having been run down by a lorry twenty years previously. At that time he was admitted to hospital, where he was treated for an avulsion injury of the thigh, back of knee, and leg, and was discharged after six months. This left him with unstable scarring of the leg.

Ten months prior to admission there was a breakdown of the scar tissue of his popliteal region which refused to heal. Biopsy showed this to be a squamous-cell carcinoma. Owing to the extent of spread of this lesion, an amputation had to be carried out.

COMMENT

This is not a rare injury, and yet it is not a well-known injury. Farmer (1939) reported on 3 cases and Stevenson (1941) quoted two such cases, when discussing skin avulsion injuries generally. Similarly, Schjelderup (1947) reported 7 cases and Mathewson and Gerber (1947) reported 5 cases. Slack (1952) published the first large series of avulsion injuries due to road accidents, and the only paper on this subject we could trace in British literature.

The apparent increase in the number of major injuries of this kind is probably accounted for by the fact that such patients are now referred to special centres for reconstructive surgery. That they are not uncommon, is in keeping with the high death-rate of the 5–15 age group of children due to road accidents.

It is significant in the aetiology of this lesion that 80 per cent occur in children, and that over 58 per cent have been casualties from bus accidents, 34 per cent from lorry accidents, and only 8 per cent from car accidents. This is in inverse proportion to the normal casualty figures for children in this region, which show a 6 per cent casualty rate due to buses, 34 per cent due to lorries and 60 per cent due to cars. The number of buses on the road is also very much less than other vehicles. To account for this difference between a 6 per cent casualty rate for children caused by buses, and a 58 per cent for avulsion injuries caused by buses, it is suggested that the lesion is more likely to be produced by a slow-moving, heavy vehicle with very wide tyres. The majority of these accidents occur in built-up areas where there is a higher concentration of both buses and children.

FIG. 720.—Camouflage by light foam-rubber prosthesis and stockings.

In the emergency treatment of these casualties, pressure dressings of tulle gras, gamgee, and crêpe

bandages, and plaster-of-Paris immobilization are advocated. The gruesome sight of injured limbs being transferred in ambulances with untidy theatre towels hanging loose, and without any form of immobilization is a too frequent occurrence. It would suggest that these cases are not seen by experienced surgeons at the casualty departments from whence they have been transferred.

We cannot agree with other writers on this subject who speak of defatting the flaps in extensive avulsions and returning them as full-thickness Wolfe grafts. There are four contra-indications to this: (1) the skin of the flaps has usually been so damaged that it cannot be used; (2) when a properly carried out excision has been completed, such a patient is not in a fit state for reconstructive surgery; (3) a far better grafting result is obtained by waiting five to seven days when a natural hæmostasis has taken place, and (4) fresh donor skin is easily obtainable with the electric dermatome.

In referring to chronic avulsion injuries, it can be well understood that surgeons who are unfamiliar with this lesion may suture back avulsed skin-flaps and have them become gangrenous within a few days. Once this has happened, however, it would be expected that the gangrenous tissue should be removed and arrangements made for repair. (It is extraordinary how often this basic principle of surgery is neglected and the case is treated conservatively for many months.)

Late results of avulsion injuries such as contractures and unstable skin may be found in any of these patients, whether early repair is performed or not, but they occur much more frequently in neglected cases.

SUMMARY

Torsion avulsion injuries of skin due to the pneumatic tyre are described, and 50 cases are recorded. These are grouped in three stages: (1) Primary; (2) Neglected; and (3) Late results, each having a different pathology and requiring different treatment. Excision of all non-viable tissues followed by reconstructive surgery, in the acute phase, is regarded as the treatment *par excellence*.

We wish to acknowledge our indebtedness to all members of the staff who were associated with these cases, and to Mr. L. Mincher for the illustrations; to the Chief Constables of Monmouthshire, Newport, and Cardiff, for road casualty figures; and to the Dunlop Rubber Company for information on the pneumatic tyre.

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THE BLOOD-SUPPLY OF THE HUMAN THYROID GLAND UNDER NORMAL AND ABNORMAL CONDITIONS

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THE results of experiments dealing with the minute vascular anatomy of the human thyroid gland have been described previously (Johnson, 1953, 1954, 1955). In the present paper the findings of these experiments are summarized and their importance in the common pathological conditions seen in the gland are discussed. This review is necessarily of a general nature and it is not proposed to discuss many of the controversial points in detail.

It is well known that changes in the physical characteristics of the thyroid gland occur frequently. The common and important examples are due to hyperplasia or involution of the vesicles of the gland. Clearly these changes of hypertrophy and involution affect the gland in either a diffuse or a patchy fashion (in the former case the result being either a diffuse hyperplastic or a colloid goitre and in the second case a nodular goitre) and the present investigation was undertaken to determine whether the vascular anatomy of the organ played any part in determining the localization of these hyper- or hypoplastic changes within the organ. It is obvious that, in order to be able to develop satisfactory theories regarding the change in vascular anatomy in the abnormal gland, one must have an adequate knowledge of the vessels in the normal tissue. For this reason the vascular bed of the normal gland was studied first. This was followed by an examination of the nodular gland and finally a histological investigation was carried out of the thyroid vessels of 200 examples of thyroid dysfunction in glands surgically removed.

HISTORICAL REVIEW

That the thyroid gland is possessed of an extremely rich blood-supply has been recognized for many years. Observations of this nature were made in the early part of the nineteenth century and at that time it was suggested that the highly vascular thyroid tissue, being superficially situated, was a cooling gland for the blood. Another prevalent idea in those days was that it acted as a buffer, protecting the brain from sudden changes in blood-flow.

It was not until almost a century later that any systematic attempts to elucidate the thyroid vascular pattern were made. Anna Bégoune in 1884 used an injection technique and made observations on

the arrangement of vessels in the normal and abnormal gland which have been subsequently confirmed. Major (1909), again using an injection technique, carried out a careful study of the vessels in normal thyroid tissue and gave a detailed and accurate account of these vessels. He, like the previous observer, regarded the thyroid gland as a lobular structure and described vessels of various orders ranging from the large superficial trunks to the small lobular artery supplying the thyroid lobule.

This concept of the lobular structure of the thyroid gland has by no means gained universal acceptance. Reinhoff (1929), as a result of a series of experiments including the construction of a wax model of the organ, concluded " that there is not the slightest evidence to indicate that the thyroid gland is lobular ". Whilst his results have been quoted in many standard texts of histology, it is doubtful if they are well founded or reliable—the results of the present series of experiments indicating that the thyroid gland is, in fact, lobular in structure (Johnson, 1953).

Modell (1933) conducted an extensive investigation into normal thyroid vessels and his results support the notion of a lobular structure of the gland. He also described arteriovenous communications between the smaller vessels of the organ, a feature of some importance in the evolution of the nodular goitre.

The capillary bed in thyroid tissue has received careful study at the hands of Williams (1937, 1944 and Lewis-Thomas (1945). These investigators, using the experimental animal (rat and rabbit) have shown that the capillary bed is highly labile, varying rapidly in its density with changes in activity of the thyroid epithelium. Lewis-Thomas describes narrow intra-epithelial capillaries in the thyroid of the rat which, he states, open up and become obvious when the epithelium is active; there is no evidence for the existence of such capillaries in the human gland.

From this it can be seen that considerable attention has been directed towards the minute anatomy of the vessels of the normal organ. However, there have been astonishingly few attempts to investigate changes occurring in pathological conditions. It should be noted that Anna Bégoune observed that the amount of blood supplied to some thyroid nodules was less than that to the gland in general; she also found that the vascular anatomy of a colloid goitre did not differ significantly from what she regarded as normal. Terry (1922) described experiments in which he injected various substances into the vessels of the nodular gland. After fixation he studied the vascular pattern in the nodules and concluded that the thyroid nodule was supplied by many peripheral vessels which penetrated the capsule of the nodule. His ideas are not entirely supported by the present experiments, which indicate that the blood-supply to a thyroid nodule is largely by way of one main artery.

Wangensteen (1929), while working in De Quervain's clinic in Berne, described injection experiments on highly vascular goitres and in these he was able to demonstrate some giant sinusoidal vessels within the nodule. Boyd (1947) has also described these giant vessels as observed in routine histological material.

MATERIAL

The material used in these experiments consisted of thyroid glands obtained from the human subject either post mortem or at operation. In the first case glands were removed from the cadaver *en bloc*, together with a mass of tissue containing the carotid and subclavian vessels. By injecting the whole specimen via these vessels satisfactory filling of the thyroid capillary bed could be obtained regularly. Glands removed at operation were found to be relatively unsatisfactory for injection methods because of the difficulty of controlling the ' bleeding ' when the vessels were injected. (Routine surgical measures were adequate in preventing loss of medium from the specimen, but the use of such measures produced so much artificial distortion of the vascular pattern that the investigation of surgical specimens was limited to microdissection and histological section.)

METHODS

In addition to the usual methods of macroscopical inspection and histological section, glands used in these experiments were investigated by other techniques, including microdissection and vascular perfusion. Glands were perfused via both the veins and the arteries, the medium used in each case being a solution of gelatin in water to which was added either carmine or barium sulphate. These techniques have been described in detail previously (Johnson, 1953).

It is found that, when investigating the anatomy of the smaller thyroid vessels, two major problems are encountered. These are concerned with the relatively small amount of connective tissue normally to be found in the gland and the relatively large size of the vesicles. That the thyroid gland contains but little fibrous tissue is a matter of simple histological observation—this feature has given rise to a great deal of confusion with regard to thyroid structure since the boundaries between the lobules of the gland are indistinct. However, it was found that the components of the gland could be separated readily by perfusing the gland for a period of about thirty minutes with normal saline; if this is done prior to the injection of the contrast medium, a vascular pattern can be readily made out. Furthermore, a routine thin section of an injected gland is of little value because few vessels are to be seen in such section; the reason for this is clear—the size of the vesicle is such that vessels situated in the spaces between the vesicles will only appear in a 7μ section over a short part of their length. If the section is increased to 150μ in thickness this difficulty is overcome—vessels being seen over a considerable part of their length (*Fig.* 721). (All the photographs of injected vessels in this paper are of 150μ unless otherwise stated.)

RESULTS

Thyroid Structure.—It is obvious that before the pattern of the blood-vessels within a tissue can be adequately described one must have a clear idea of the structure of that tissue. As has been stated already, there has been some difference of opinion on this point, but accumulating evidence indicates that the gross unit of structure of the thyroid gland

is the lobule. The details of thyroid structure may be set out as follows :—

a. The Anatomical Lobe.—The anatomical lobe of the adult human thyroid is a pyramidal structure situated in the lower half of the neck, immediately lateral to the trachea, and deep to the sternomastoid and strap muscles. The details of its anatomical form and relationships need not concern us here. It consists of a collection of many disk-shaped areas of tissue bound together in a fibrous-tissue sheath—the capsule of the thyroid gland. The individual disk of tissue is termed a 'structural lobe'. These are readily rendered apparent within the anatomical lobe by perfusing the gland with saline. This makes the tissue 'œdematous', thus separating the structural lobes from each other (*Fig.* 722).

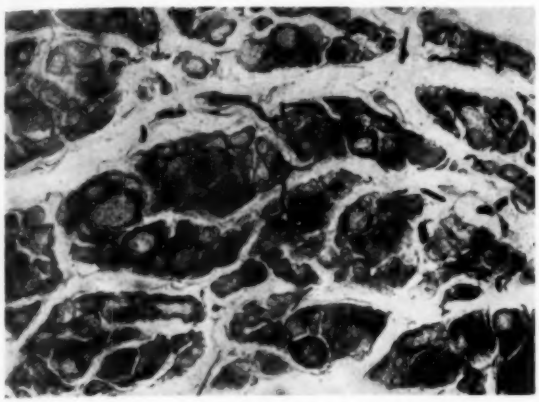

FIG. 721.—Photomicrograph of a section of injected normal thyroid gland. The structural lobes and lobules which characterize adult thyroid architecture are clearly seen. Note that in this 150μ section arteries may be seen over a considerable portion of their length. (× 10.)

b. The Structrual Lobe.—These are the irregular disks of tissue which are to be seen quite readily when a section is taken of injected material and examined either macroscopically or microscopically (*Fig.* 721). Many of them, closely packed, make up the anatomical lobe as usually recognized. Each individual structural lobe is further subdivided into many lobules.

c. The Thyroid Lobule.—The thyroid lobule is to be regarded as the unit of structure of the thyroid gland. It is an irregular mass of tissue consisting of 20–40 vesicles bound together by a very fine sheath of connective tissue. Occasionally a gland is encountered where this connective-tissue sheath is more obvious and, should this be the case, the lobules will be seen in routine histological section. They form, by their aggregation into disks of tissue, the structural lobe of the thyroid gland and may be further subdivided into their component vesicles.

Lobules are observed without great difficulty in injected material (*Fig.* 723) and, if care be taken, may be microdissected intact from a piece of thyroid tissue.

These observations are shown diagrammatically in *Fig.* 724.

The Vascular Anatomy of the Normal Thyroid Gland.—The thyroid gland receives its blood-supply from four and occasionally five major arterial trunks, that is, the superior and inferior thyroid arteries and the inconstant *A. thyroidea ima.* The anatomical course and variations of these vessels are too well known to require repetition here. They run to the gland, divide, and course over its surface before plunging into its substance. As they ramify on the surface these vessels anastomose frequently —a fact which is obvious to the most casual observer.

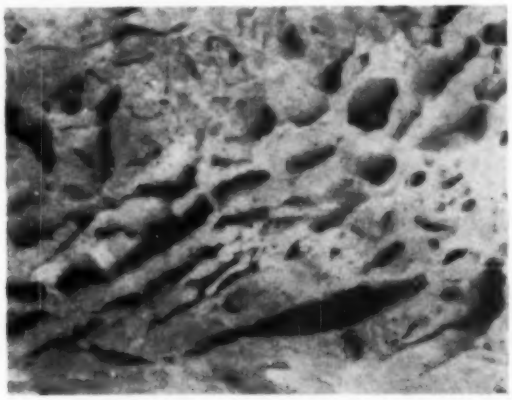

FIG. 722.—Photograph of the cut surface of an 'œdematous' normal thyroid gland. The gland is rendered 'œdematous' by perfusion with normal saline for a period of thirty minutes. Collection of fluid in the connective tissue separates the structural lobes from each other, as is shown in this photograph. (× 6.)

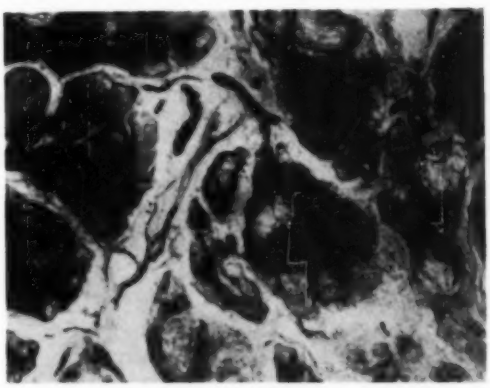

FIG. 723.—Photomicrograph of a section of injected normal thyroid gland. The photograph illustrates a thyroid lobule, shown here in the middle of the picture with its lobular artery entering at its upper pole. (× 20.)

Branches arising from the major trunks plunge into the depths of the glands where they run in the fibrous septa between structural lobes. Whilst in this site, further subdivision occurs and branches of the interlobar vessels pass into the structural lobe where they divide into branches supplying the thyroid lobules (*Fig.* 725). It is to be emphasized at this point that each lobule receives its own individual twig, designated the lobular artery. Occasionally one finds a lobule with two small vessels entering it, but this finding, because unusual, does not detract from the general principle of one lobule, one artery.

Within the thyroid lobule the lobular artery breaks up into a series of twigs passing to the vesicles.

On reaching the vesicle these twigs divide and form a capillary plexus on its surface (*Fig.* 726). The density and arrangement of this plexus varies from vesicle to vesicle, and it is important to appreciate that the pattern at any given time is related directly to the activity of the epithelium (Williams, 1944).

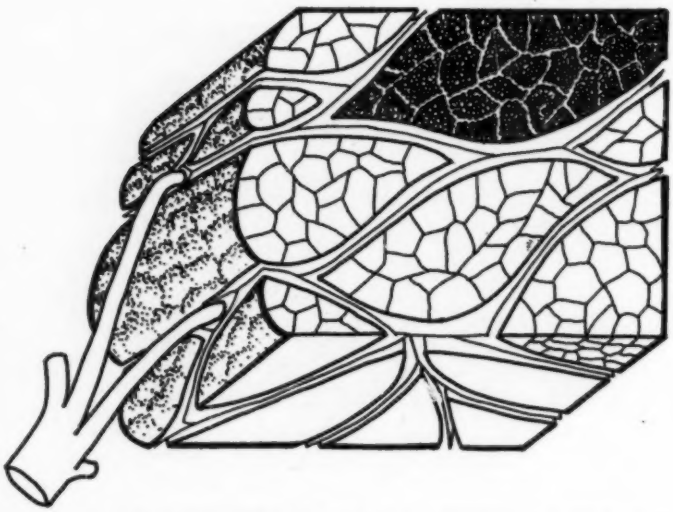

FIG. 724.—Diagram showing the structure of a block of thyroid tissue, including an area on the surface of the gland. It is seen that the gland is made up of structural lobes (the large disk-shaped areas seen in the diagram). In some of these no further subdivision is shown; in others the subdivision to lobules is illustrated. Structural lobes are aggregates of thyroid lobules—many of which are illustrated in the diagram—and in one structural lobe the vesicles contained in the thyroid lobules are indicated. The branches of a vessel on the surface of the gland are shown entering the gland and running in the septa between structural lobes.

FIG. 726.—Photomicrograph of a section of injected normal thyroid gland. A thyroid vesicle surrounded by its capillary plexus is clearly seen. (× 150.)

The anatomy of the veins can be demonstrated readily by retrograde injection via the major venous trunks of the neck—when this is done it is found that the pattern displayed is essentially the same as that described for arteries. A small venous twig is formed by the confluence of the vesicular plexus; several twigs from the lobule unite to form the lobular vein, which, on leaving the lobule, runs toward the surface following the pathway described for the larger arteries.

Anastomoses occur between various vessels in the gland—they are of the following types:—

Arterial: The occurrence of surface anastomoses between major arteries has already been described. There is also considerable evidence to show that

FIG. 725.—Diagram illustrating the details of the blood-supply to the normal thyroid gland. A large surface vessel sending a branch between structural lobes is represented. Branches from the interlobar vessels enter the structural lobes where further subdivision to supply the thyroid lobules occurs.

arterial anastomoses also occur between vessels in the depths of the gland, although these are more difficult to demonstrate. In the present experiments anastomoses have been observed to occur between lobular arteries just before they enter the thyroid lobule (Johnson, 1953).

Venous: Venous anastomoses occur frequently both on the surface and in the depths of the gland; they are readily demonstrated and there is no difference of opinion as to the frequency of their occurrence.

Arteriovenous: In the present investigation only indirect evidence has been obtained for the occurrence of arteriovenous anastomoses within the thyroid gland. Modell (1933) has produced good evidence that these anastomotic channels do occur in the thyroid gland of the dog. Moreover, the highly vascular pulsating gland seen in thyrotoxicosis, with its typical bruit and elevated oxygen content of its veins, gives strong support to the hypothesis that arteriovenous anastomoses are present and functioning in this condition.

Thus it is seen that the thyroid gland is possessed of a relatively complex vascular bed by way of which blood is distributed to its component lobules. These vessels are subject to vasomotor control and may therefore vary in calibre under the influence of nervous stimuli; further, the presence of inter-arterial and arteriovenous shunts within the gland substance would allow of considerable variation from time to time in blood-flow to the lobules.

THE NODULAR GOITRE

The Evolution of the Thyroid Nodule.—Evidence regarding the evolution of the nodule may be obtained in several ways. The simplest method technically is histological examination of sections taken from a series of thyroid glands which contain nodules in various stages of development. From a practical point of view it is easier to begin with the well-developed nodule and work towards small and minute structures, since, in so doing, one begins with a gross, and therefore easily recognizable, condition. When this is done it is found that, as the nodules examined become smaller and smaller, there is a progressive diminution in the number of constituent vesicles associated with a steady reduction in the amount of perinodular fibrous tissue (*Fig.* 727). These changes may be followed until it is

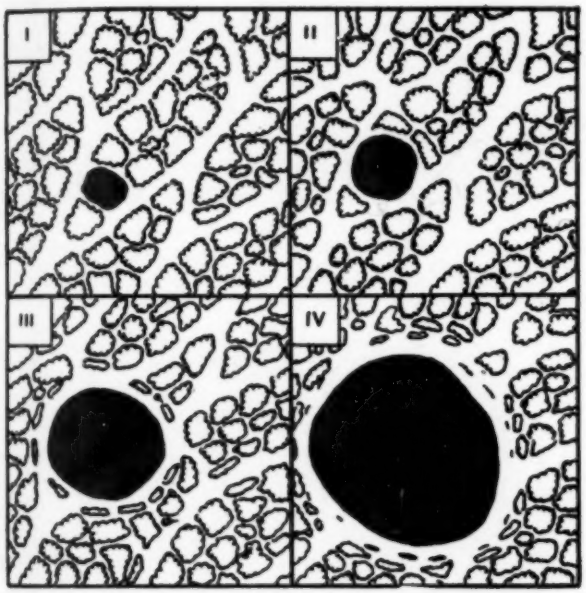

FIG. 727.—Diagram of a series of sections of thyroid tissue showing the evolution of the thyroid nodule. In (I) a section of tissue with structural lobes and lobules is indicated. One thyroid lobule (represented in black) undergoes progressive enlargement and becomes a thyroid nodule. In (II) the lobule has increased only slightly in size. In (III) and (IV) further increase in size associated with the disappearance of surrounding thyroid tissue and the increase in amount of perinodular fibrous tissue is to be seen.

seen that the smallest nodules are indistinguishable from the larger thyroid lobules.

Injection methods aid in the demonstration of these small nodules; a section cut from an 'œdematous' thyroid containing small nodules will show, on macroscopical inspection, that these small nodules are obviously within the structural lobes (*Fig.* 728). Thick sections of these 'œdematous' preparations show that the nodule has a blood-supply quite separate from that of the rest of the gland, there being a clear, uninjected zone surrounding the nodule and separating it from the rest of the thyroid tissue. (This clear zone seen in injected material is quite obviously the fibrous capsule of the nodule.) In fortunate sections, the artery of supply to the nodule can be seen crossing this clear zone. Thus it can be demonstrated that:—

a. Small nodules and large lobules are histologically indistinguishable;

b. The small nodule, like the normal thyroid lobule, has a surrounding capsule of connective tissue;

c. The small nodule, like the lobule, is supplied by a single artery which crosses to it from the nearby normal gland.

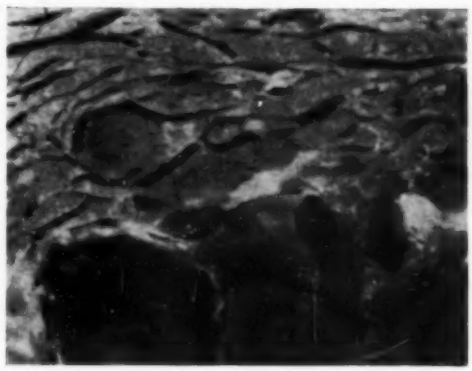

FIG. 728.—Photograph of the cut surface of an 'œdematous' thyroid gland containing many small nodules. Close inspection of the surface shows that the small nodules develop within the structural lobes and as they increase in size they distend and distort that structure (cf. *Fig.* 722). (× 6.)

With this evidence in hand it is reasonable to assume that the nodule as commonly recognized in the thyroid gland is, in fact, merely an enlarged thyroid lobule.

Moreover, in fresh glands it is found that relatively small nodules (up to 1–2 cm. in diameter) can be readily shelled out of the surrounding connective tissue, being attached at only one point—the hilum. As the nodule increases in size, and particularly if degenerative changes occur within its substance, this simple pattern becomes lost, since associated reactive changes result in the invasion of the capsular space by new vessels growing in from the surrounding thyroid tissue. This suggests that Terry (1922) made observations principally on nodules showing secondary changes.

Development of Vessels within the Thyroid Nodule.—Associated with the increase in size of a thyroid nodule there is an obvious development of many new thyroid vesicles. Individually, vesicles or groups of vesicles may possess the morphology associated with activity or involution of the component epithelium, but this, for the moment, may be ignored. If the arrangement of these vesicles, rather than their individual appearance, be studied, it is found that the vesicles do not show lobular arrangement (which is such a constant feature of the adult gland).

Thus it may be stated that as a nodule develops the proliferating vesicles attain an architectural complexity different from that which characterizes the adult gland.

Associated with the less complex histological arrangement a correspondingly less complex vascular pattern is found. Section of an injected nodule (when viewed under low-power magnification) shows that, instead of the complex picture of vessels arranged to supply structural lobes and lobules, there is a

simple irregular branching vascular tree (*Fig.* 729). Here and there a suggestion of lobular formation may be observed but, conforming with hyperplastic changes seen in liver, kidney, and other organs, the attempt at normal organization always falls far short of that seen in the adult gland.

In some examples of nodular goitre a group of nodules with a common capsule is found. This

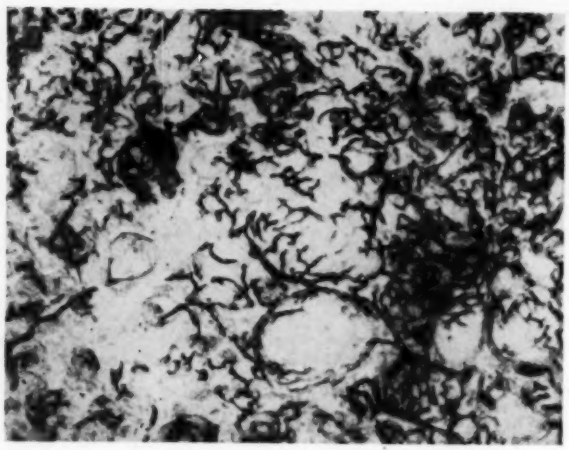

FIG. 729.—Photomicrograph of a section of unstained injected nodular goitre showing the vascular pattern within the nodule. Numerous vesicles with partly filled capillary plexuses are seen, but there is no evidence of lobule formation as is seen in the adult gland (cf. *Fig.* 721). (× 25.)

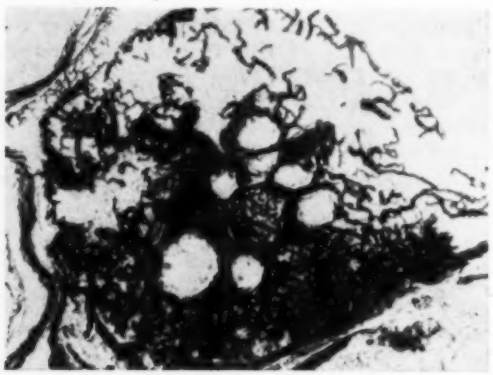

FIG. 731.—Photomicrograph of an unstained injected nodular goitre showing an area of dilated sinusoidal capillaries within a thyroid nodule. The vascular pattern in these areas is quite different from that seen in the normal nodule (*Fig.* 729) and histological section shows that this vessel pattern occurs in areas of epithelial activity (cf. *Fig.* 732). (× 12.)

almost certainly represents the development of several nodules within a structural lobe, rather than the formation of lobules within a developing nodule, since within the limits of the material examined for these experiments, no intermediate stages of nodules containing newly formed lobules have been observed.

Changes in Vessels around the Nodule.—Close observation of the capsule of a thyroid nodule will reveal that many relatively large vessels occur in it. Terry (1922) noticed these perinodular vessels and concluded that they formed the blood-supply to the thyroid nodule. By following the evolution of the vessels in a series of injected glands containing nodules of increasing size, their true significance becomes apparent. Histological examination shows that, as a thyroid nodule increases in size, the surrounding thyroid tissue disappears and the nodule develops a capsule of connective tissue in which the large vessels are found. Injection methods reveal that, as thyroid lobules and lobes disappear, the complex vascular bed associated with

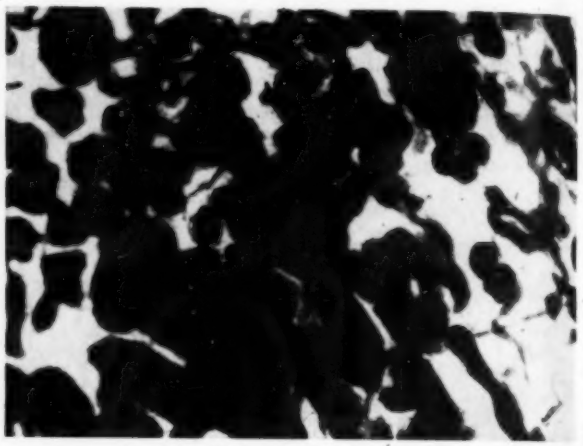

FIG. 730.—Photomicrograph of a section of injected nodular goitre showing a collection of giant vessels within a thyroid nodule. Note the gross variation in size of these vessels and the fact that small vessels of capillary size open directly into them. (× 50.)

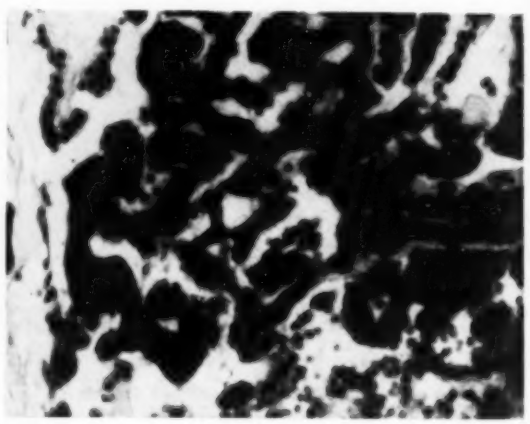

FIG. 732.—Photomicrograph of a routine stained section of an injected nodular goitre. The section is taken from the same area as is seen in *Fig.* 731. While the cytological detail is poor (due to lack of fixation during period of perfusion) the relation of the dilated vessels to columns of thyroid cells is readily observable. (× 250.)

them is modified so that vesicular plexuses and smaller arteries and veins are lost and are replaced by the simple capillary bed characteristic of connective tissue. The vessels of lobular artery size and larger are seen to persist (presumably because they supply more than merely vesicles and lobules), and it is these larger vessels which are seen in the capsule of the nodule.

Changes in Vessels of the Nodule.—The evolution of the thyroid nodule has been discussed, and it has been shown that its vascular pattern presents a simple irregularly branching system which, after several subdivisions, gives off twigs to

individual vesicles. There has been no evidence that new lobules (characteristic of adult thyroid tissue) are formed within the thyroid nodule. If the intranodular vessels are examined histologically it is found that, by and large, they possess a normal structure (Johnson, 1955). Occasionally, however, giant thin-walled vessels may be observed within the thyroid nodule; these vessels occur particularly within nodules having the histological features of many small vesicles separated by loose acidophil 'œdematous' connective tissue (the nodules often being referred to as 'fœtal adenomata').

On histological examination little idea can be gained either of the extent or the function of these vessels. Injection experiments demonstrate them much more adequately (*Fig.* 730) and show that they occur with considerable frequency in the type of nodule mentioned above. They are thin-walled (often being lined merely by a layer of endothelium surrounded by a thin condensation of connective tissue), and possess but little mechanical strength (as is demonstrated by their frequent rupture during perfusion experiments). Vessels of capillary size can often be observed opening directly into these large vessels.

A second change in the intranodular vessels occurs in association with areas of epithelial activity. Routine histological examination gives little indication of the vascularity of such areas, but a combination of the methods of injection and histological examination shows that these areas possess an extremely rich blood-supply by way of multiple tortuous dilated thin-walled sinusoidal vessels (*Figs.* 731, 732). These areas appear to develop as a modification of the existing capillary bed.

In perfused glands it is found that, whenever either of these two types of change occurs in the intranodular vessels, then that part of the vascular bed involved in the processes under the conditions of the experiment acts as an intranodular arteriovenous shunt. This observation is considered to be of considerable importance, particularly when seeking explanation of hæmorrhage and necrosis in thyroid nodules.

DISCUSSION

The questions posed, when one attempts to explain the localization of unusual changes within a tissue, are problems of general pathology. In many cases a difference occurs in a local area because the stimulus producing the change acts only, or principally, on that local area. However, when the stimulus is a more general one, it is often found that the degree of localization of response is astonishing. Thus it is found that the damage produced in the tissue of the kidney and liver (as judged by the later stages of chronic nephritis and cirrhosis) occurs in a strikingly irregular fashion considering that the toxic agent in most cases is blood-borne.

Furthermore, hyperplastic changes in the breast, myometrium, and thyroid gland are known to occur in either diffuse or localized forms and the factors determining the distribution of the changes are little understood. In the case of the thyroid gland, something is known of the stimuli capable of producing changes in the thyroid epithelium. For example, iodine lack, thyroid-stimulating hormone, and drugs of the thiourea group will all produce changes of thyroid epithelium activity; often these changes are uniform, often they are patchy.

In seeking explanation of the localization of these changes it is clear that there are at least two possible explanations:—

1. That, while the stimulating agent (being blood-borne) is of uniform concentration the cells of the target organ vary in their ability to respond to that stimulus and so a patchy response is produced;

2. That variations in the incidence of the stimulating agent on different areas of the tissue are produced by variations in blood-flow to these areas.

Although a difference in 'susceptibility' of cells is well recognized in some cases (as, for example, in bone where some parts are growing more rapidly than others) there is not sufficient information available to suggest a difference between different cells or groups of cells in the adult organ. We must therefore discount the first hypothesis in the present case. Turning now to the second hypothesis, evidence has been presented to show that the normal thyroid gland is a lobular structure and that each lobule receives a small artery as its vessel of supply. It is also known that anastomotic channels occur between the small arteries (of lobular size) and between arteries and veins within the substance of the thyroid tissue. Now it is highly probable that both the lobular artery and the anastomotic channels described above are under the influence of both chemical stimuli and vasomotor impulses delivered by way of vasomotor nerves to the gland. Thus there exists a functional arrangement which permits of variations in blood-flow to an individual lobule either by reducing the diameter of the lobular artery or by the shunting of blood away from the lobular artery before it enters the lobule. Clearly at this stage of our knowledge further information is needed to prove these hypotheses—the point to be made, however, is that the anatomical arrangement is of such a type that alterations in blood-flow to various areas in the gland may cause significant changes in adjacent parts of the gland and thus provide means by which a stimulus of constant intensity in the blood-stream could affect the gland tissue in a patchy fashion.

Further it has been demonstrated that the source of the thyroid nodule is the thyroid lobule. A lobule becomes a nodule merely by becoming larger than its neighbours, irrespective of whether that increase in size be due to involutionary or hyperplastic changes within its component vesicles. It has been shown that the thyroid tissue around the evolving nodule becomes distorted and that its lobules disappear, leaving in their place only fibrous tissue and vessels. The vascular bed formed within the evolving nodule and the two types of change to be found in the nodular vessels have been described. The most important observation on these intranodular vessels is that, when either giant sinusoidal vessels or areas of dilated tortuous vessels are present they act as intranodular arteriovenous shunts. The result of this is that no perfusion medium at all enters the vascular bed of the nodule surrounding these areas. Now clearly during life the rest of the nodule must receive a blood-supply, and so it is pertinent to examine the ways in which the conditions of an

experimental perfusion differ from those prevailing during life. The perfused gland in the experiments described here has deliberately been allowed to stand at room temperature for eighteen hours before perfusion is attempted, and during this time any post-mortem spasm (rigor mortis) exhibited by the smooth muscle in the arterial walls will have disappeared. Thus, in the conditions of experimental perfusion, the path taken by a medium will depend on relatively simple hydrodynamic factors and in the circumstances the phenomena described above are observed. However, during life there are at least two additional factors at work. These are: (*a*) that the blood-flow is pulsatile; (*b*) that the vessels within the gland are under control of vasomotor impulses. It is highly probable that vasomotor control in the living tissue restricts entry of blood into the low-resistance areas formed by these changed intra-nodular vessels and determines its flow into the rest of the nodule.

A further point deserves mention. The routine pressure of perfusion in these experiments was 200 mm. Hg, and, in such circumstances, no example was observed of rupture of the arterial tree in the normal gland—even when the pressure was increased to 300 mm. Hg no arterial rupture could be produced. On attempting to perfuse a normal gland via the vein it is found that venous rupture occurs at a pressure of 80–100 mm. Hg. Turning now to the nodular thyroid, it was found that extravasation of medium into the nodular tissue occurred frequently when the arterial pressure was 250 mm. Hg. There are two possible explanations of this difference:—

1. That the arteries of the nodular gland are mechanically weaker than those of the normal gland (an idea for which there is no evidence);

2. That, here again, is evidence of the operation of an intranodular arteriovenous shunt whereby medium at high pressure escapes into the venous side of the circulation, thereby causing vessel rupture.

These phenomena have a bearing on the problems of hæmorrhage and necrosis within the nodular gland. It has been shown that blood-flow to a given thyroid nodule depends on a combination of vessel pattern and vasomotor control.

Alterations in vasomotor control could produce the changes in blood-flow to the nodule in the following ways:—

1. The calibre of the nodular artery may be altered;

2. Pre-nodular arteriovenous or interarterial communications may open or close;

3. Intranodular arteriovenous shunts may deviate a quantity of blood away from areas within the thyroid nodule over a short or longer period of time. During this period degenerative changes may occur in the ischæmic tissue which may be so severe that they amount to frank necrosis;

4. Intranodular arteriovenous shunts may, when open, allow the pressure within giant vessels to become raised above 100 mm. Hg and thus result in hæmorrhage within the thyroid nodule.

'It is a matter of simple observation that both sudden changes (with the occurrence of hæmorrhage and necrosis) and gradual changes (with progressive atrophy and perhaps cyst formation in areas within the nodule) occur frequently in thyroid nodules. The present study has shown that the vascular bed is of sufficient complexity in its anatomical and physiological arrangement to account for many of these changes.

SUMMARY

1. A group of human thyroid glands (both normal and abnormal) has been investigated with particular reference to the smaller thyroid vessels.

2. The vascular tree in the normal gland has been shown to follow a well-defined pattern. Progressive branching occurs until ultimately each thyroid lobule receives its own vessel of supply.

3. Evidence is presented to show that the thyroid nodule is merely an hypertrophied thyroid lobule.

4. The vascular beds of the developing nodule and of the thyroid tissue surrounding that nodule are described.

5. The development of giant vessels and sinusoidal vessels within the thyroid nodule is noted.

6. The significance of these changes with respect to the development of the thyroid nodule and the occurrence of degenerative changes within that nodule is discussed.

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STONES IN PYELOGENIC CYSTS

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A CONSIDERABLE literature has grown up concerning the cyst-like structures which lie adjacent to, or in communication with, the renal caliceal system. The variety of terms which has been used to describe these entities reflects the lack of certainty concerning their aetiology. Most authors regard these cyst-like spaces as arising from the renal collecting system—hence the term 'pyelogenic cyst' (Damm, 1932). Other titles suggested include hydrocalicosis (Watkins, 1939), caliceal diverticulum (Prather, 1941), partial hydronephrosis (Fenger, 1873), intrarenal cyst (Köhler, 1933), calectasis (Engel, 1947), ectopic calix (Kemp, 1954), while Braasch and Emmett (1951) also list encysted cortical stone and secondary simple cyst or abscess which has ruptured into or communicates with the calix.

FIG. 733.—Excretion urogram showing hydrocalicosis of upper minor calix. (Mr. Alex Roche's case.)

Hydrocalicosis (*Fig.* 733) has been defined as a localized dilatation of one or occasionally more than one calix, minor or major, but there is no dilatation of the renal pelvis, and the unaffected calices are normal. Usually the upper or lower calices are involved. On pyelography there is either a smoothly outlined almost circular shadow tapering to a well-defined narrow neck communicating directly with the renal pelvis or a dilatation more obviously consisting of a major calix and meriting Fenger's term 'partial hydronephrosis' (*Fig.* 734).

Such an hydrocalicosis may be associated with stone formation; its neck may be plugged by a stone (*Figs.* 735, 736) or the dilated calix may contain stones (Stewart, 1953). A solitary stone may have been responsible for the dilatation by irritation and intermittent obstruction, but multiple stones suggest previous dilatation and stasis in the cavity. In the absence of stones or other apparent cause for the hydrocalicosis, such as a neoplasm or a parapelvic cyst (*Fig.* 737), muscular dysfunction at the infundibulum is postulated.

FIG. 734.—Excretion urogram showing hydrocalicosis of upper major calix. (Mr. Harland Rees's case.)

The term 'caliceal diverticulum' has been used when the caliceal system is normal apart from its communication with the smooth cystic space lying in the renal parenchyma. Some have described this space as an ectopic calix (*Fig.* 738). In good radiographs a long narrow neck can be seen (*Fig.* 739), but this communication is not always obvious, especially on excretion urography. The aetiology is obscure, and stone formation is not uncommon. Such cysts are lined by transitional epithelium, but this may be partially or wholly destroyed by calculi. These caliceal diverticula must be distinguished from the ulcero-cavernous stage of tuberculosis (*Fig.* 740), where the cavity is often ragged and

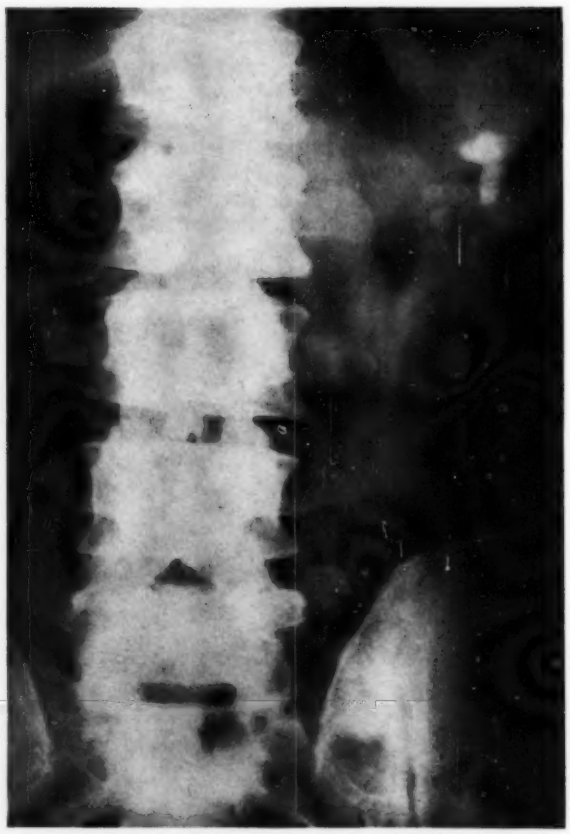

FIG. 735.—Excretion urogram showing hydrocalicosis due to stone. (Mr. J. G. Sandrey's case.)

FIG. 737.—Retrograde pyelogram showing hydrocalicosis due to a parapelvic cyst. (Mr. J. Burke's case.)

irregular. Necrotizing papillitis, which occurs most commonly in diabetic subjects, may also be confused, but in this condition the calices are blunted; nevertheless, as Wall (1954) illustrates, a great similarity may exist.

Occasionally the communication between the cyst-like space and the caliceal system becomes

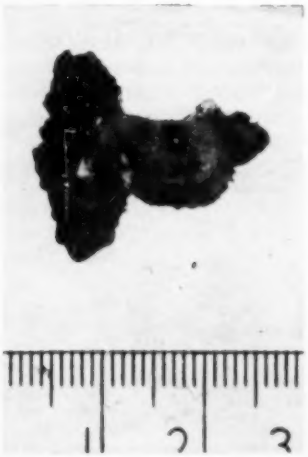

FIG. 736.—The stone shown in *Fig.* 735 after removal.

obliterated, perhaps by irritation and fibrosis associated with stone formation, and then a closed cyst, lined by transitional epithelium, results. This is a true pyelogenic cyst, arising from the collecting system, and is to be distinguished from a congenital cyst formed of fibrous tissue lined in whole or in part by cuboidal cells. It seems that these cyst-like spaces most commonly present in one of three ways:

FIG. 738.—Bilateral retrograde pyelograms showing ectopic calix. (Mr. D. I. Williams's case.)

(1) when there is an obvious dilatation of one calix which directly communicates with the pelvis or a major calix; (2) when there is a cystic dilatation which is not in the usual position of either a major or minor calix, but communicates with the caliceal system; and (3) when there is a small cyst adjacent

to the caliceal system but not directly communicating with it. We believe that these are all variations of the same theme and that these variations are due mainly to different aetiological factors, but perhaps also to different anatomical development of the particular caliceal system. Each of these groups can well be included under the comprehensive term of 'pyelogenic cyst'.

The main purpose of this paper is to report 2 cases of open pyelogenic cyst with stone formation

FIG. 739.—Excretion urogram showing caliceal diverticulum communicating by narrow neck with upper calix. (Mr. Cameron MacLeod's case.)

both requiring operative treatment by local resection, and also an unusual case of calculi in closed pyelogenic cysts with congenital cysts in the same kidney. These three patients were treated at St. Peter's Hospital for Stone.

CASE REPORTS

Case 1.—**Caliceal diverticulum with stones; local excision.**

A man aged 25 years had hæmaturia for two days, but no other urological symptoms. Physical examination was negative. His urine was sterile but contained a trace of blood and pus. Further examination for tubercle was negative. An excretion urogram showed that there were three small calculi lying in a cavity in relation to the upper major calix of the right kidney (*Fig.* 741). This finding was confirmed on retrograde pyelography and the lateral picture taken in this instance gives better indication of the size of the cavity and of its relation to the upper major calix (*Fig.* 742).

AT OPERATION (Mr. F. R. Kilpatrick).—Under general anæsthesia the right kidney was exposed through the bed of the twelfth rib. A small artery running to the upper pole was divided. The pedicle was exposed and the vessels controlled with a rubber-covered clamp. The renal capsule was incised and reflected over the anterior surface of the upper pole of the kidney. The cystic space containing the stones was identified and excised together with the calculi. The communication between the cavity and the renal pelvis was identified and closed by means of a catgut transfixion ligature. A fat pedicle graft was sutured into the resulting cavity and the capsule closed over it.

PATHOLOGICAL REPORTS.—The calculi were composed of phosphates and oxalates.

HISTOLOGY.—The sections of the tissue removed do not show any abnormality other than congestion and small hæmorrhages. (There is no epithelium to be seen in the sections.)

FIG. 740.—Retrograde pyelogram showing ulcerocavernous stage of tuberculosis. (Mr. H. K. Vernon's case.)

FOLLOW-UP.—An excretion urogram six months after operation showed a normal kidney. The patient was well when last seen a year after operation, and the urine was sterile.

Case 2.—**Caliceal diverticulum with stones; partial nephrectomy.**

A man aged 46 years had had recurring attacks of urinary infection for two years. Excretion urography showed two small calculi in a urine-containing cavity; this lay in the renal parenchyma opposite a minor calix which arose from the upper major calix of the right kidney. Retrograde pyelography confirmed these findings and demonstrated the connecting channel between the calculus-containing space and the minor calix (*Fig.* 743). While under investigation the patient had a further episode of urinary infection associated with rigors and a temperature in excess of 102° F.

AT OPERATION (Mr. Harland Rees).—Under general anæsthesia the right kidney was exposed through an oblique muscle-cutting incision in the loin. The renal artery was found to divide early and to supply the kidney in distinct upper and lower groups. The vessels to the upper part of the kidney were doubly ligated and divided and the upper three-fifths of the kidney, including the stone-containing cavity, were removed. The line of suture was oversewn and the capsule closed over it.

PATHOLOGICAL REPORTS.—The stones were composed of phosphates and oxalates; the histological appearances

of the tissue removed were identical with those of the previous case.

FOLLOW-UP.—This patient last reported a year after operation and had had no recurrence of urinary infection.

FIG. 741.—Excretion urogram showing stone-containing cavity. (*Case* 1.)

FIG. 743.—Retrograde pyelogram showing dye in cavity containing stones. (*Case* 2.)

Case 3.—**Multiple cysts of kidney with stone formation; nephrectomy.**

A man aged 57 years had had several attacks of urinary infection in the past. A twelve-year interval had

FIG. 742.—Lateral retrograde pyelogram. (*Case* 1.)

intervened before the onset of the attack which brought him for treatment. On examination his left kidney was palpable but was not tender and the urine contained a trace of blood; it was sterile. A preliminary radiograph showed multiple calculi in the left kidney. An excretion urogram demonstrated that some of these stones were in the dilated upper calices. There was a possible parapelvic cyst. Other calculi did not appear to be in the caliceal system and were found to have moved their position in the pre-operative radiograph.

AT OPERATION (Mr. A. W. Badenoch). Under general anæsthesia a left nephrectomy was done (*Fig.* 744).

PATHOLOGICAL REPORT.—The large cyst was found to contain oxalate calculi. There were also smaller cysts at the upper pole. The cut surface of the kidney revealed further cysts, including another large cyst containing oxalate calculi (*Fig.* 745). Dr. Cuthbert Dukes was not able to demonstrate any communication between these cysts and the caliceal system. Other stones were found in the dilated upper calices. The two largest cysts were lined by transitional epithelium and surrounded by a fibrous-tissue capsule. A cyst from the lower pole showed no epithelial lining. The two types of cyst wall are illustrated (*Fig.* 746).

Comment.—This case is of particular interest because of the unusual combination of two types of cyst in the one kidney. It would seem that the two larger cysts which contained oxalate calculi and were lined by transitional epithelium must have communicated at some time with the caliceal system and are thus closed pyelogenic cysts. On the other hand the smaller cysts which had no epithelial lining were probably of congenital origin.

DISCUSSION

Aetiology.—The experimental production of renal cysts is an interesting problem. Over fifty years ago Luzzato (1900) claimed to have produced

cysts in rabbits by injecting the renal papilla with iodine. Petersen, Tollens, and others (Caulk, 1911), however, have failed after attempts to destroy the papilla by various means. Latteri (1930) buried strips of the pelvis of the opposite kidney in the renal cortex and produced cysts in dogs. Hinman and Hepler (1926) produced an hydrocalicosis by a combination of infarction and ureteric obstruction. Hepler (1930), in one rabbit only, produced a solitary cyst eighteen days after tying the posterior branch of the renal artery and fulgurating the papilla.

Partial occlusion of the renal artery with the object of producing hypertension, in a series of some two hundred rabbits, unexpectedly gave rise to a type of renal cyst in two animals (Daniel, Prichard, and Ward-McQuaid, 1954). Six weeks after applying the clip both rabbits had subcapsular cysts, associated with small areas of cortical infarction, and containing some 10 ml. of fluid. Presumably a subcapsular effusion had occurred during the process of infarction.

The theories of the aetiology of pyelogenic cysts and allied conditions have been discussed by many writers including Fenger (1873), Damm (1932), Köhler (1933), Quinby and Bright (1935), Hyams and Kenyon (1941), Dorsey (1949), Moore (1950), and Mathieson (1953). The theories fall into two groups, the congenital and the acquired. The acquired group results, according to most writers, from various kinds of mechanical blockage, such as by stone or by fibrosis secondary to infection. Macalpine (1949), however, does not postulate an obstructive element; he states, "The cavity appears to arise as a dilatation around a stone or stones lying in the parenchyma, possibly in a tubule, and the connection with the pelvis is perhaps by a dilated duct of Bellini". This is, of course, analogous with the encysted cortical stone of Braasch and Emmett. Where no mechanical factor is detectable achalasia of the musculus sphincter calicis is postulated. We have nothing to add to these contributions.

FIG. 744.—Closed pyelogenic cyst containing stones. (*Case* 3.)

FIG. 745.—Cut surface of kidney showing multiple cysts, stones in upper calix, and in closed pyelogenic cyst. (*Case* 3.)

FIG. 746.—Photomicrograph showing pyelogenic cyst lined by transitional epithelium (R.), and congenital cyst without lining (L.). (*Case* 3.) (× 204.)

Management.—Treatment becomes necessary only in the presence of complications such as infection and hæmaturia, usually associated with stones.

In many cases a caliceal diverticulum is an incidental finding and can then be ignored, though its presence may be of significance should urinary infection subsequently develop. In the absence of symptoms we see no necessity for repeated urograms as has been advocated by some writers. When there are symptoms, these usually take the form of recurrent episodes of urinary infection, a persistent nagging pain in the renal angle, and hæmaturia.

A patient presenting with urinary infection who is found on radiography to have a caliceal diverticulum, uncomplicated by stone, should be treated conservatively by the appropriate chemotherapeutic agent. Repeated attacks of infection require more active treatment. Stone formation associated with pain and hæmaturia is probably best treated by operation, though Wyrens (1953) included in a series treated conservatively a case in which a stone was present. The result was satisfactory and there was no recurrence of symptoms up to the date of his report.

More conservative measures have generally replaced nephrectomy, which was the original operative treatment of pyelogenic cysts. Four types of conservative operation have been advocated: (*a*) nephrostomy and dilatation of the sclerosed neck; (*b*) pyelostomy and dilatation; (*c*) local excision; (*d*) partial nephrectomy. In addition Beneventi (1943) has reported the relief of symptoms and the reduction in the size of an hydrocalix by means of repeated dilatation of the neck by the passage of a catheter up the ureter and into the cavity. This method is too uncertain for regular use.

Among those who have used dilatation and nephrostomy are Prather (1941), and Wilhelmi (1949). The neck of the caliceal diverticulum is dilated and a tube inserted through the renal cortex and via the dilated neck into the renal pelvis; the tube is retained for ten days. Satisfactory results demonstrated by radiography have been obtained. This method has also been successful when the nephrostomy tube has been omitted, and dilatation of the infundibulum from the pelvis has also given good immediate results (Sandrey, 1954).

Local excision of the caliceal diverticulum was used with good effect in *Case* 1. It has been described in the case report and does not require further discussion except, perhaps, to emphasize the necessity for accurate identification of the communication flush with the renal pelvis.

Partial nephrectomy was used in *Case* 2 and has been advocated, amongst others, by Engel (1947), Newman, Lowman, and Waters (1952), and Landes (1953). It is nowadays the operation generally done for this condition.

Beneventi's method is too uncertain to find general acceptance; nephrostomy and dilatation has given satisfactory results in several published cases, as has pyelostomy and dilatation, but it is more likely to be followed by residual infection than are the more certain methods of total excision of the infected cavities. Of the two methods of total excision partial nephrectomy is preferable when the lesion is in either the upper or lower pole of the kidney, but the method of local excision is of value when the pyelogenic cyst lies in relationship to the middle major calix, as in this situation the method of intrarenal distribution of the major branches of the renal artery makes formal partial nephrectomy impracticable.

In conservative operations appropriate chemotherapy should be employed to prevent infection in the remaining portion of the kidney.

SUMMARY

1. The nomenclature of cyst-like structures adjacent to the renal caliceal system is discussed.

2. Two cases of open pyelogenic cyst with stone formation and an unusual case of calculi in closed pyelogenic cysts with congenital cysts in the same kidney are reported.

3. The treatment of pyelogenic cysts and allied conditions is discussed.

We are indebted to the surgeons who have allowed us to report the case histories and reproduce the radiographs of patients under their care. We wish to thank Dr. C. E. Dukes for histological reports. Our thanks are due to Mr. A. Finch, of the Institute of Urology, for preparing the illustrations.

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SURGICAL TREATMENT OF CYSTIC DISEASE AND EMPHYSEMA IN YOUNG CHILDREN

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CYSTIC disease and obstructive emphysema of the lung are commonplace in adults and older children and their recognition and treatment forms part of the routine work of any Thoracic Unit. When they occur in the early weeks or months of life, however, the tiny patient's hold on life may rapidly become precarious and effective treatment may present urgent and well-nigh insoluble problems.

The following cases are recorded in the hope that some of these difficulties may be illustrated.

CASE REPORTS

Case 1.—An 8-week-old female infant (M. B.) was transferred to the Thoracic Surgical Unit on Aug. 19, 1953, from a Babies' Hospital where she had arrived three weeks previously *in extremis*. The child had been breathless and somewhat cyanosed, more especially on feeding since birth. Pregnancy and labour had been normal and the child's respirations had become established without any resuscitatory measures. Periodic breathless and cyanotic attacks had been followed at the age of five weeks by a particularly severe episode when the child was rushed to hospital where the last rites were performed in the belief that death was inevitable. Revival, however, occurred with oxygen therapy. Rapid wheezing respirations and left-sided twitchings were noted. Clinically the mediastinum was displaced to the right and a radiograph of the chest was interpreted as showing a left-sided pneumothorax or a tension cyst (*Fig.* 747). In an attempt to relieve this, and to improve the child's desperate condition, a needle connected to a water-seal drain was inserted into the left chest. Very little air escaped by this method, but when the needle was removed a well-marked surgical emphysema rapidly developed over the neck and upper chest. Gradual improvement occurred with oxygen and antispasmodics but variations occurred and the child's condition remained precarious.

On admission to the Surgical Unit, breath-sounds were still much diminished over the left chest and radiographs showed an apparent tension cyst filling the left hemithorax and herniating over to the right. It was decided not to needle this again because of the risk of converting the condition into a tension pneumothorax. Operative treatment was selected in view of the likelihood of the child developing another severe cyanotic attack. On Aug. 25, 1953, under nitrous oxide, oxygen, and trilene anæsthesia (Dr. Pollock) a preliminary bronchoscopy showed deviation of the trachea to the right, extreme narrowing and angulation of the left main bronchus, but no evidence of a foreign body.

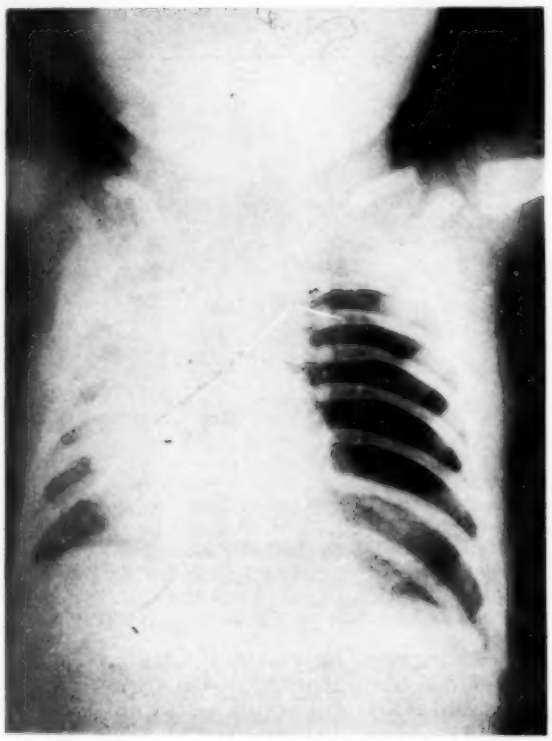

FIG. 747.—*Case* 1. Eight-week-old infant. Left upper lobe grossly distended. Mediastinum markedly displaced to right side.

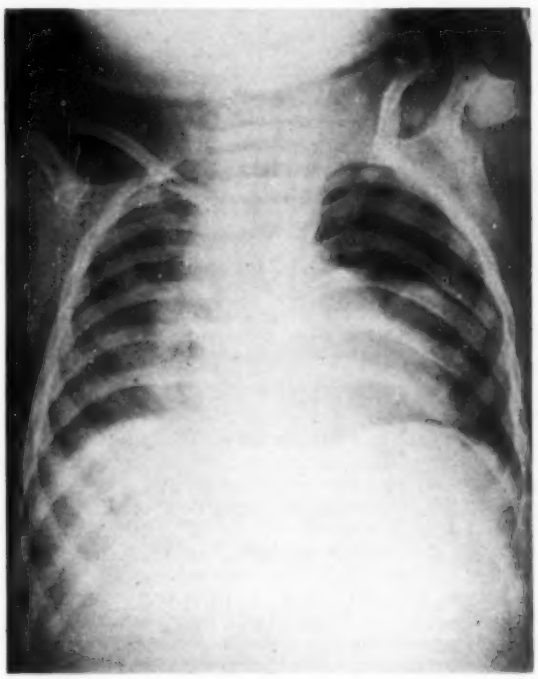

FIG. 748.—*Case* 1. At age 1 year. Mediastinum central. Left lower lobe fills the whole of the left pleural cavity.

The anæsthetist then passed an endotracheal tube and the child was turned on her right side and a thoracotomy performed (P. J.) through the left fifth intercostal space. The appearance of the lung was remarkable. The left upper lobe was uniformly grossly distended and filled the whole hemithorax and burst its way out of the chest as the incision was made. Closer inspection showed the lobe to be emphysematous and crepitant, while small bubbles of air could be seen running freely under the

visceral pleura. The lower lobe was quite atelectatic. No cause could be found for this unusual finding, and furthermore the anatomy of the hilar structures was normal. There seemed to be no alternative but to resect the upper lobe and this was, therefore, performed uneventfully by the usual dissection technique. The lower lobe aerated gradually during the operation and at its conclusion looked normal. An intercostal drain connected

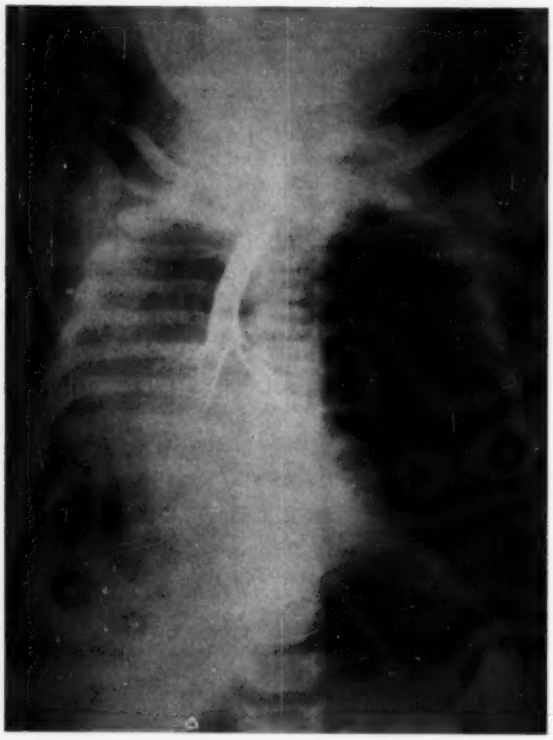

FIG. 749.—*Case* 2. Four-month-old child. Trachea and main bronchi outlined by contrast medium. Left upper lobe fills whole of left pleural cavity and extends into right side. Trachea markedly displaced to right.

to a water-seal bottle assisted the further expansion of the remaining lobe. Post-operative radiographs showed the immediate return of the mediastinum to a central position, with progressive expansion of the left lower lobe to fill the left chest cavity. The child did well for three months post-operatively but then developed an acute tracheobronchitis with marked bronchospasm, and once more became severely ill. Antispasmodics and antihistaminics produced slight improvement but eventually she appeared to respond to cortisone. A year later the child shows normal development, but displays a marked allergic response to certain foods (*Fig.* 748).

Case 2.—A 4-month-old male child (V. W.) was admitted to hospital on Nov. 9, 1953, with a history that he had been noticeably dyspnœic since the age of two weeks, particularly on crying and on feeding, with evidence of cyanosis around the lips. These symptoms were thought to be progressive. The child's delivery had been normal, birth weight 7 lb. 6 oz. after a normal pregnancy. One sibling aged 5 years was well. Examination on admission revealed obvious dyspnœa with movement of the alæ nasæ. Cyanosis was evident on crying. The mediastinum was displaced to the right and the right chest was moving visibly more than the left, while air entry on auscultation was much diminished in the left lung. Radiologically a large cystic area was noted filling the left hemithorax (*Fig.* 749) and the child was kept under observation. On Nov. 17 a bronchogram was made by injecting 2½ c.c. Neohydriol down an endotracheal polythene tube. This failed to demonstrate the left bronchial tree, but showed that the right side was normal. The following day the child was severely dyspnœic with indrawing of the sternum and lower ribs with moist sounds to be heard in both lungs. Penicillin and atropine produced some improvement though the child remained dyspnœic and cyanosed. Thoracotomy was decided upon and performed (F.R.E.) on Nov. 28. The left upper lobe was found to be voluminous, filling most of the left chest and extending over into the right hemithorax. The lower lobe was poorly expanded. The left upper lobe was resected by the individual ligation

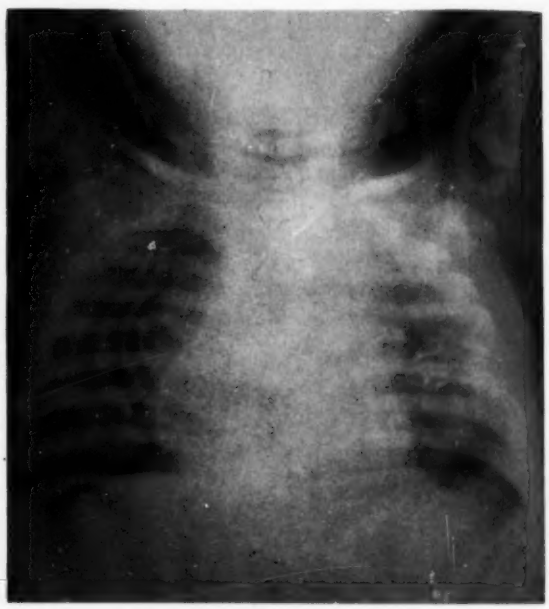

FIG. 750.—*Case* 2. Post-operative radiograph. Mediastinum now central. Left lower lobe fills left pleural cavity.

technique, tube drainage to a water-seal bottle being instituted on concluding the operation. Post-operatively the mediastinum became central and the left lower lobe expanded to fill the left hemithorax. The child's symptoms were completely relieved and six months later the family physician reported that the child was developing normally and was very well (*Fig.* 750).

Pathology.—The resected lobes in these two cases were almost identical in that they were grossly overdistended by obstructive emphysema and were uniformly spongy in appearance. The individual pathologists recorded a similar description, stating that there was generalized emphysema throughout the resected lobe, with areas of interstitial emphysema (*Fig.* 751). In *Case* 1, however, the structure of the bronchi was apparently normal, whereas in *Case* 2 no cartilage could be demonstrated in the bronchial walls.

Pre-operatively the above cases presented the same features of severe respiratory embarrassment and in each case the diagnosis was believed to be cystic disease, probably a large solitary cyst which had undergone valvular obstruction in its communicating bronchus. *Cases* 3 and 4 also presented with marked respiratory distress, but radiologically the diagnosis was more easily determined.

Case 3.—A 6-month-old female baby (S. H.) was admitted with a history of episodes of dyspnœa and cyanosis since birth. The depth of cyanosis had been variable, but with attacks of ' bronchitis ' the child became severely embarrassed. She had previously been admitted elsewhere in one of these attacks and had recovered after a period in an oxygen tent. Examination revealed diminished air entry with some moist sounds in the right lung, while radiologically there was well-marked cystic disease of the right lower lobe, with mediastinal displacement to the left (*Fig.* 752). The child was operated upon (J. S. G.) on July 25, 1953, under endotracheal anæsthesia after premedication by rectal thiopentone. Thoracotomy

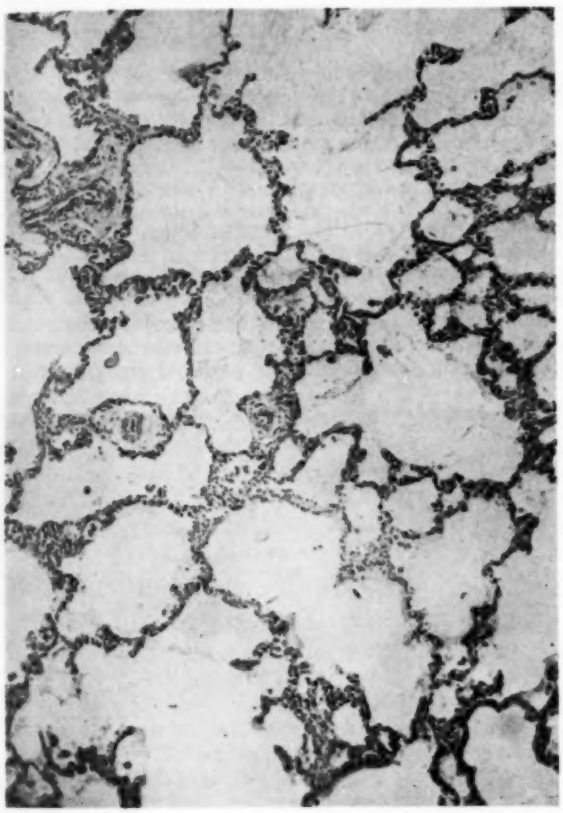

FIG. 751.—*Case* 1. Photomicrograph of typical area of emphysematous lung showing the disruption of alveoli which has taken place as the result of great overdistension. (× 30.)

showed that the whole of the right lower lobe was replaced by a cyst which was under considerable tension. In order to allow the upper and middle lobes to expand and thus improve the child's oxygenation, the cyst was incised and deflated, after which a routine dissection lobectomy was carried out to remove the lower lobe. The remaining lobes were found to fill the pleural cavity at the end of the operation and the chest was, therefore, closed without drainage. The child's convalescence from this procedure was uneventful (*Fig.* 753).

PATHOLOGY.—The specimen showed that the excised lobe was completely replaced by a single cyst through which remnants of bronchi and blood-vessels passed to traverse the cavity to reach the outer wall, thus forming trabeculæ which had been visible on the radiographs.

Case 4.—This was a 10-month-old male child (B. R.) admitted to hospital on Nov. 18, 1952, in severe respiratory distress. The previous history showed that the child was delivered at term normally, weighing 9 lb. 7 oz., and up to the age of 6 months no abnormality had been suspected. From time to time a persistent cough had developed varying in severity. Exposure to measles had occurred three weeks before admission. On Nov. 15, the child became feverish, drowsy, and irritable, and refused feeds. During the next day the cough became

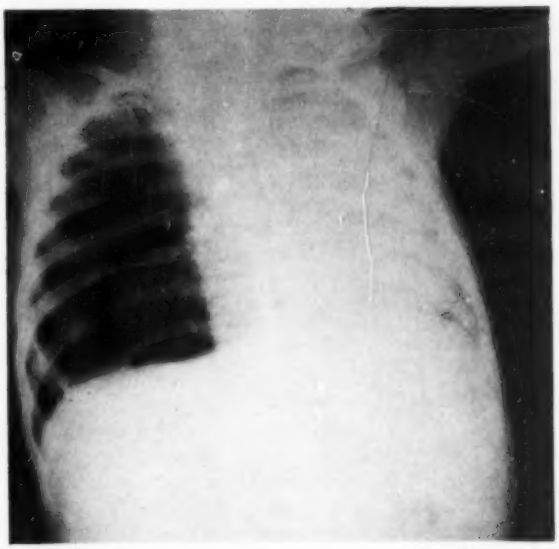

FIG. 752.—*Case* 3. Six-month-old child. The right pleural cavity is occupied by the overdistended cystic middle and lower lobes, which extend across the midline producing mediastinal displacement to the left.

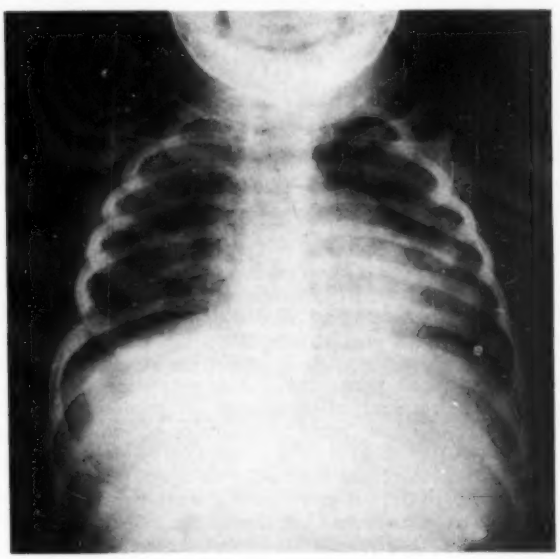

FIG. 753.—*Case* 3. The mediastinum is now central and the right upper lobe has expanded to fill the right chest.

worse and seemed to exhaust him. A rash appeared on the face and hands. Measles was suspected and oral sulphathiazole was commenced. The child deteriorated and was transferred to hospital on the third day of the illness.

On admission the boy was evidently very ill, deeply cyanosed, and with rapid shallow respirations : Temperature 99·8° F., pulse 136, respirations 50. There was an atypical rash on the chest and back. Breath sounds were impaired and somewhat moist in both lungs. There was some meningismus. Bronchopneumonia was diagnosed. However, the following day, a chest radiograph (*Fig.* 754)

showed extensive cystic disease throughout the right lung, with marked mediastinal displacement to the left. A small localized right pneumothorax was also present. A throat swab grew only normal respiratory flora. It was considered, therefore, that the child was suffering from congenital cystic disease of the right lung which had become secondarily infected, with the development of

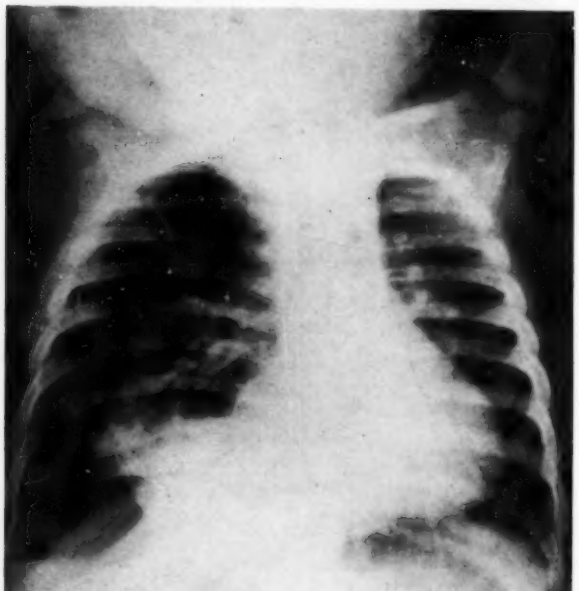

FIG. 754.—*Case* 4. Ten-month-old boy. Grossly cystic right lung. Basal pneumothorax. Some mediastinal displacement to left.

tension in the cysts, one of which had ruptured into the pleural cavity. Emergency resection of the lung appeared to offer the only chance of survival.

A preliminary bronchoscopy was carried out and some thick tenacious mucopus aspirated from the right main bronchus. The child was then placed in the lateral position and a rapid thoracotomy carried out (J. F. D.). The tense cystic lung at once herniated out through the wound. As soon as the lung was displaced, however, in order to apply a clamp to its main bronchus, the trachea became blocked with thick and exceedingly tenacious pus which resisted all attempts to aspirate it. This calamity resulted in complete occlusion of the air passages of the opposite lung, which could not be overcome, and consequently the child died before the operation could be completed. The autopsy showed that the structure of the left lung was normal but that it was largely atelectatic. There was extensive cystic disease throughout the right lung, with mediastinal adenitis. No other abnormality was found.

Case 5.—A 5-month-old boy (P. H.) was admitted to hospital with a history of respiratory distress which had eventually culminated in a pneumonic episode. He was apparently quite normal until the age of six weeks, when he became noticeably restless and cried after feeds. His breathing was frequently noisy and somewhat laboured and he vomited occasionally. This persisted for about three weeks, after which his respirations became grunting in character and he became hot and listless.

He was admitted to the nearest hospital at the age of nine weeks, when his temperature was found to be 101° F., pulse 136, and respirations 30/min. Blood-count showed Hb 63 per cent, R.B.C. 3·9 million, W.B.C. 10,000. The Mantoux reaction was negative 1 : 1000. Radiographs at this stage showed a circular translucency in the apex of the left lower lobe with a surrounding area of infiltration. The temperature subsided, the general condition improved, and the infiltration cleared radiologically with chemotherapy, leaving a solitary cyst in the left lung which was believed to be congenital rather than inflammatory in origin. Despite the child's general improvement, aeration of the left lung remained limited and the now thin-walled cyst in the apical segment of the left lower lobe (*Fig.* 755) continued to increase in size, leading to obstructive emphysema of the basal segments of the left lower lobe and mediastinal displacement to the right. Although the child was not grossly dyspnœic it was felt that the mechanics of respiration would soon become sufficiently upset to make further temporization hazardous.

A thoracotomy was, therefore, carried out (J. S. G.) on Nov. 10, 1954. The left lower lobe was found to be moderately distended and, although the cyst was not obvious on inspection of the lobe, its site could be determined by palpation. It was decided to remove the lower lobe and this was accomplished by the normal individual ligation technique, the vascular supply of the lobe being normal. Subsequent convalescence was uneventful and it was clear that the child's respirations had become more normal with much more satisfactory air entry of the remaining left upper lobe.

The pathologist reported that the lobe contained a cyst involving most of the apical segment, while the neighbouring lung tissue was replaced by a number of

FIG. 755.—*Case* 5. Five-month-old boy. Well-marked solitary cyst arising in the apical segment of the left lower lobe, producing obstructive emphysema of the basal segments together with mediastinal displacement to the right.

smaller cysts. The lining of the cysts examined microscopically was composed of ciliated epithelium varying between cuboidal and columnar in type. There was no doubt of the congenital origin of these cysts.

REVIEW OF LITERATURE

The literature contains numerous reports of cases of various types of cystic disease and emphysema in young children. Overstreet (1939) appears to have been the first in modern times to have drawn attention to a separate pathology, namely that of congenital abnormality of a lobar bronchus giving rise to uniform distension of a whole lobe. In his historical review, Overstreet, however, refers to

such a case being described by Peeler and Phillips in 1922 in which an 8-week-old infant was found to have a localized emphysema of the left upper lobe believed to be due to constriction of the lobar bronchus. Overstreet's case was a four-week-old male child, also with an emphysematous upper lobe. An attempt was made to relieve the child's respiratory distress by inserting a tube into the left lung. The post-mortem examination showed a deficiency of cartilage in the posterior wall of the upper-lobe bronchus, whereas the lower-lobe bronchial cartilage formed a complete ring. The theory was that the abnormally developed L.U.L. cartilage had in some way prevented air returning from the L.U.L.

Gross and Lewis (1945) described the interesting case of a 7-week-old female child which had a grossly emphysematous right upper lobe which had partially pushed its way into the left chest through a defect in the anterior mediastinal pleura. An exploratory thoracotomy at the age of 8 weeks was abandoned because of the child's poor condition, but the emphysematous right upper lobe was successfully resected four years later and the mediastinal defect repaired. The lobar bronchus was said not to contain any cartilage, though no histological report was given.

Leahy and Butsch (1949) discuss the pathogenesis of obstructive emphysema in young babies. They refer to Wasson (1924), who made a detailed radiological study of the gradual aeration of babies' lungs during the days after birth and who emphasized that birth trauma could produce areas of atelectasis interspersed with areas of emphysema. They suggested that vigorous resuscitation after delivery might well produce unsuspected pulmonary damage. In this regard, they quote Salmon, Forbes, and Davenport (1947), who performed necropsies on 6 infants who were found to have died from pneumothorax and emphysema after forced hyperventilation to resuscitate the babies at birth.

Leahy and Butsch described such a child, seen at the age of 11 weeks, who had been subjected to mechanical resuscitation at birth. Respiratory symptoms became obvious at the age of six weeks. At 14 weeks a typical emphysematous left upper lobe was resected. Histologically the lobe contained patchy emphysema with areas of atelectasis. They list thick secretion, infection, and mucosal flaps among the causes of obstructive emphysema, though the two former may produce a transitory type of obstruction which tends to resolve spontaneously.

Evans (1949) stated his belief that congenital atresia or stenosis can occur in the bronchi just as they can in the trachea or any other viscera. He then described 4 cases of cystic disease in children and 1 case of agenesis of one lung. One of these cases survived resection of the left upper lobe for a cyst; the remainder died, two of them after surgery.

Robertson and James (1951) described 5 cases (all under 1 year of age) who suffered from true obstructive emphysema. In 3 cases the right upper lobe was involved, in 1 case the left upper lobe, and in 1 case the right middle lobe. The first case, a boy of 3½ months, seen in 1933, died in a cyanotic attack, surgical intervention being out of the question in those early days. Necropsy showed valve-like folds in the right upper-lobe bronchus. All five cases were typical in having suffered repeated attacks of respiratory difficulty and cyanosis from birth without febrile episodes. Two of the cases were treated by needle aspiration of the apparent tension cyst or pneumothorax. One 9-month-old child died from the tension pneumothorax which developed after the aspiration. In the other case, an 11-month-old baby, this error was recognized and water-seal drainage instituted. The child recovered, and the offending emphysematous right middle lobe was resected successfully two years later. In the two remaining cases, both boys, one 2 weeks and the other 8 weeks old, a grossly distended emphysematous upper lobe was successfully resected from each. Apart from the first case, the causative lesions could not be determined.

Shaw (1951) pointed out that localized obstructive emphysema occurs quite frequently in young children owing to obstruction of lesser bronchi by thick secretions, and this may produce an obvious difficulty in diagnosis. (Nor can one ignore the ever-present risk of obstruction due to foreign body.) Shaw adds 2 further examples in young children, one involving the apico-posterior segments of the left upper lobe in a 4-year-old boy who had had respiratory difficulty and a translucent left hemithorax from the age of two weeks. The second was a 7-week-old female whose right middle lobe was involved. Both cases were successfully resected.

Lewis and Potts (1951) describe another case of a boy aged 4 months who was successfully operated on for a large emphysematous right middle lobe which was associated with an anterior mediastinal defect. It was suggested that rotation of the middle lobe towards the left chest kinked and partially obstructed its bronchus. No other abnormality of its bronchus could be found.

Fischer, Potts, and Holinger (1952) survey the literature in detail and report 5 successful resections in young babies of their own. In 4 cases an upper lobe was involved and in the fifth the right middle lobe. In addition to deficiencies in bronchial cartilages or valvular folds in the mucosa they suggest that some degree of obstruction may be produced by abnormal vessels, and in 2 of their cases an unusually fibrous and unyielding ductus arteriosus was divided to relieve pressure on the main bronchus though the involved left upper lobe was also resected. As a possible explanation for cases where no cause can be determined, they put forward an interesting theory. They postulate the theory that if any degree of obstruction of the main bronchus should occur, then since the abdominal and intercostal muscles compress principally the lower part of the chest, and since the upward rise of the diaphragm compresses the lower lobe directly, then air may be forced out of the lower lobe and into the upper lobe during violent efforts of coughing. The upper lobe, therefore, becomes overdistended and emphysematous. (It is difficult to see, however, why air should remain in the upper lobe unless there is also some abnormal valvular mechanism in its bronchus.) To add further credence to this theory these writers point out that, so far, cases of true obstructive emphysema have only been described in the upper and middle lobes and not in the lower lobes.

Sloan (1953) reports 4 more cases of emphysema, all under three months of age, one being only six days old. In 2 cases the left upper lobe was involved, while in the other 2 the right middle lobe was successfully resected.

Finally, d'Abreu (1953, a) records 1 case of a child first seen at the age of 3 months, but kept under observation until operation at the age of 2 years,

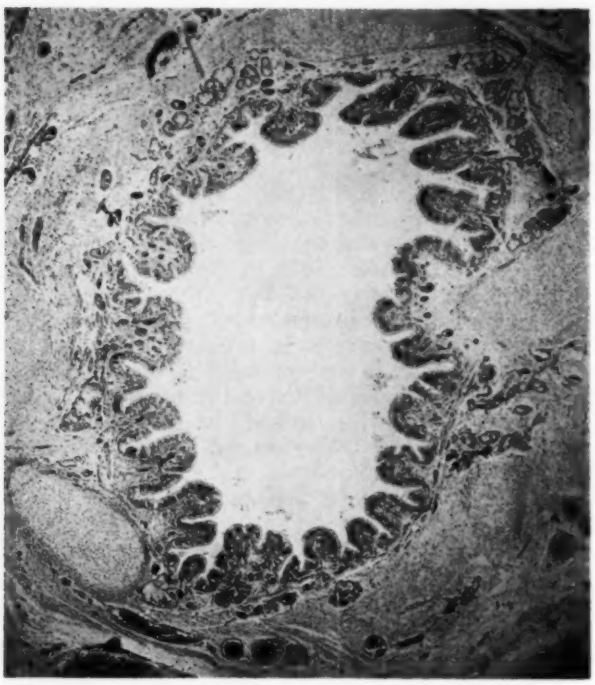

FIG. 756.—Cross-section of lobar bronchus from stillborn child, showing well-marked mucosal folds. (× 25.)

when a grossly emphysematous left upper lobe was resected. The upper lobe bronchus in the case was found to consist of fibrous tissue only. d'Abreu (1953, b) also refers to other similar cases, one aged 4 weeks, which were successfully treated by resection.

DISCUSSION

These 5 cases have been presented in order to illustrate some of the features which appear to be more or less typical of obstructive emphysema and cystic disease of congenital origin in young children. It has already been well demonstrated in the American literature that babies can be submitted to and do tolerate lung resection operations should these be considered necessary.

The case histories of these cases were very similar in that all five were noted to suffer some degree of respiratory difficulty from an early age which was progressive in character and accompanied by varying degrees of cyanosis. The dyspnœa and cyanosis were much more pronounced during feeding—or on crying. During the early stages there was no evidence of infection, nor was there any suggestion in the emphysema cases that the condition could have been provoked by forceful resuscitatory measures at birth, for they both breathed spontaneously.

Unfortunately in *Case* 1 a radiograph was not available from the initial period and, indeed, had one shown emphysema in the first two weeks of life some difficulty might have been experienced in distinguishing it from the transitory emphysema which occurs in young babies owing to obstruction of their small bronchi by thick secretions as described by Shaw (1951).

FIG. 757.—Cross-section of lobar bronchus from newborn child whose lungs have expanded and aerated. The bronchial wall is bounded on three sides by cartilage, whereas the posterior wall contains smooth muscle to allow contraction. (× 25.)

Various theories of causation of severe obstructive emphysema have been described, and in some the presence of mucosal flaps or the absence of normal cartilage in the bronchi (*Case* 2) have been demonstrated.

Examination of sections of bronchi in newborn babies shows that the mucosa is normally thrown into folds until the lung has become well aerated, when the bronchi expand both in length and diameter (*Fig.* 756). It is conceivable that such folds may persist for a time and be mistakenly regarded as a cause of obstruction. Furthermore the normal lobar bronchi resemble the trachea in cross-section (*Fig.* 757) until they enter the lung and subdivide into segmental bronchi and then their walls contain circularly arranged plates of cartilage (*Fig.* 758).

In other cases, however, no anatomical cause of obstruction could be found, and in view of follow-up histories of bronchitis and asthma it seems likely that severe bronchospasm possibly due to an allergic tendency may be a factor (*Case* 1).

It is, of course, most important to distinguish a distended cyst or obstructive emphysema from tension pneumothorax radiologically, for, while needle aspiration will produce rapid relief of the

latter it may convert the former into a tension pneumothorax with a rapidly fatal result unless the error is speedily recognized (Robertson and James, 1951). Should this mistake be made a catheter should be inserted into the pneumothorax space at once and connected to an under-water drain.

It remains a curious fact that congenital obstructive emphysema affects the upper lobes or the right middle lobe but, so far as can be discovered, no case has been reported in which a lower lobe has been involved. Fischer, Potts, and Holinger (1952) drew attention to this and suggested that the lower chest and abdominal muscles contract the lower lobes more forcibly than the upper lobes, and if any minor obstruction should be present in the main bronchi

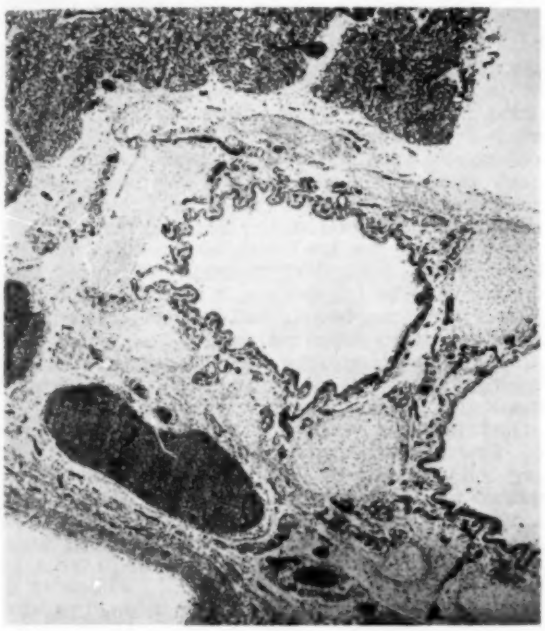

FIG. 758.—Cross-section of segmental bronchus. The bronchial wall is evenly supported by circularly arranged cartilage plates. (× 25.)

then the upper lobes, being at a mechanical disadvantage, become inflated. Perhaps one might add to this the suggestion that in the young child the lower ribs are very much more mobile and allow much more complete compression of the lower lobes, whereas the upper lobes are more shielded from contraction beneath the more firmly suspended upper ribs, and thus the upper lobes cannot be contracted in as effective a manner as the lower lobes and under great provocation may in fact be blown up in a balloon-like fashion. It becomes evident that once the condition has become established, the distended lobe is structurally grossly damaged and unless it can be deflated or removed, the mechanics of respiration are so greatly interfered with that the patient cannot survive. Surgical excision appears to offer the only solution to this problem.

Much the same course of events may ensue in congenital cystic disease. It is, however, important at the onset to distinguish the latter from those forms of cysts which make their appearance during an acute infection, particularly staphylococcal septicæmia or pneumonia, though such cases have no previous history of respiratory distress and respond promptly in most instances, where the responsible organism is sensitive to the appropriate antibiotic therapy. The 3 cases reported here had not suffered from any earlier febrile illness, but displayed slowly increasing dyspnœa, presumably owing to the gradual distension of the abnormal lung, until they were showing severe respiratory distress. A mild respiratory infection may undoubtedly accelerate such a course and this was well illustrated by *Cases* 4 and 5. Where there is a history of progressively increasing dyspnœa and cyanosis, together with the radiographic appearances of cystic disease, even in a young baby, one feels there is a strong argument for advising surgical treatment before infection supervenes, for this complicates the problems by increasing bronchial secretions, thus making surgery much more hazardous. Comparison between *Cases* 3 and 4 demonstrates this conclusively.

It is conceivable that *Case* 4 might have proved a less difficult anæsthetic problem had the patient been operated on in the face-down position, though even this would not have overcome the problem of sucking out thick secretions from the lower trachea, for cases are encountered where the bronchi become obstructed with material so viscid and glue-like as to resist the most powerful suction.

SUMMARY

Two cases of congenital obstructive emphysema and 3 cases of congenital cystic disease in young babies under 1 year of age are reported. These were submitted to surgery on account of severe respiratory distress. One child failed to survive the operation. The literature describing the surgery of these cases is reviewed and attention is drawn to certain aspects and difficulties of diagnosis and treatment.

Sincere thanks are offered to Mr. Frank Nicholson, Mr. Ronald Edwards, Mr. J. S. Glennie, and Mr. J. F. Dark for allowing me to report on their cases. I should also like to thank Miss Gibbon, of the South Manchester Hospitals Group, for reproducing the radiographs and the photomicrographs.

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INTESTINAL ENDOMETRIOSIS

WITH SPECIAL REFERENCE TO INVOLVEMENT OF THE CÆCUM AND THE OCCURRENCE OF INTUSSUSCEPTION

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ENDOMETRIOMA of the cæcum is rare and the occurrence of an intussusception due to such a lesion must be excessively so. Intestinal endometriosis commonly affects the sigmoid colon, more rarely the ileum, and more rarely still the cæcum. We have been able to find records of 43 cases of endometriosis of the cæcum in the literature. These may be grouped into three categories :—

1. Those with definite evidence of endometrioma.
2. Those with diffuse involvement of the ileocæcal region.
3. Those cases in which passing reference only is made as to involvement of the cæcum by endometriosis.

Blair-Bell (1922) defined an endometrioma as "a localized area of endometrium-like tissue bearing characteristic glands, stroma, and occasionally smooth muscle and thriving in an unnatural site". We have found reports of 9 cases of endometrioma of the cæcum. Adams-Ray (1933) reported 1 case associated with 3 other separate endometriomata in the sigmoid. Irons, Judd, and Dockerty (1947) reported 1 personal case and found 2 others in the pathological museum at the Mayo Clinic. Their review of the literature included 3 other cases reported by Waugh, Masson, and Sanders respectively. Shemilt (1949) reported 1 case of a localized endometrioma of the cæcum which was found to be obstructing the lumen of the appendix and had caused a mucocele of that organ. Finally, Warmoes (1951) reported a case of chronic cæcocolic intussusception due to a cæcal endometrioma.

We have also found reports of 4 cases of diffuse ileocæcal endometriosis : Colcock and Lamphier (1950) 2 cases, Kinder (1954) 1 case, and White (1954) 1 case. The remaining 30 cases belong to the third or unclassified group. Thus Masson and Cariker (1944) report 14 cases, Counsellor and Sluder (1945) 13 cases, and Thierstein and Allen (1946) 3 cases.

We have only been able to find 2 reports of intussusception associated with endometriosis, though several authors (Patton and Patton, 1941 ; Kinder, 1954) refer to the possibility of its occurrence. One of these cases has already been mentioned (Warmoes, 1951). The other (Cuningham and Smith, 1948) was a case of irreducible ileo-ileal intussusception into the cæcum caused by an endometrial nodule situated in the ileum.

Recently a patient was under our care who, at operation, was found to be suffering from an intussusception caused by an endometrioma of the cæcum. The rarity of this condition, and the instructive clinical features presented by the patient, require a full report of the case.

CASE REPORT

A married woman, aged 43, was admitted to St. Luke's Hospital, Bradford, on Feb. 1, 1954, complaining of acute abdominal pain of nine days' duration. She said that for the past eighteen months she had had similar attacks of pain, which began on the first day of her menstrual period and usually lasted for 3–4 days, but that since Jan. 22 pain, similar in nature to her previous attacks, had persisted and "would not wear off". She described the pain as a colic, situated in the central abdomen and left iliac fossa. The pain had been severe enough to disturb her sleep, and she was aware of a sensation as if a swelling "like a ball" was present in the left side of her abdomen. She said that during the previous bouts of pain her bowels were usually constipated, but she had not noticed any blood in her stools. In the present attack she felt nauseated, but had not vomited, and this time the bowels had opened regularly. No urinary symptoms were noticed.

MENSTRUAL HISTORY.—Periods regular 6/24. No dysmenorrhœa until 18 months ago, when bouts of comenstrual abdominal pain commenced.

OBSTETRIC AND MARITAL HISTORY.—Married 24 years ago. One stillborn child twenty-one years ago. Two living children aged 18 and 13. Normal births in each instance. No dyspareunia.

PREVIOUS HISTORY.—The patient had had two abdominal operations. The first was carried out ten years ago and the patient was told that a perforated ovarian cyst and her appendix had been removed. Following this operation the patient had intermittent aching pain in the right iliac fossa and in the region of the wound. The pain did not coincide with menstruation, and was not associated with nausea or vomiting. Her bowel habit remained unchanged during this time. Owing to persistence of symptoms a second operation was carried out in July, 1952, and numerous adhesions surrounding the cæcum were divided and the cæcum freed. A localized hæmorrhagic area was found in the wall of the cæcum and the possibility of endometriosis was considered at this time. The patient's present symptoms of cyclical bouts of abdominal pain date from the first menstrual period that followed recovery from the second operation.

ON EXAMINATION.—The abdomen was moderately distended and a firm, tender, mobile oval-shaped swelling was present in the left iliac fossa. Rectal examination revealed no abnormality. Pre-operative diagnosis was twisted pedicle of ovarian cyst.

AT OPERATION.—On Feb. 1 the mobile swelling was found to be an intussusception of the cæcum and terminal ileum into the colon. This was reduced without difficulty and a hard irregular swelling, thought to be a carcinoma, was found in the cæcum. A short-circuiting side-to-side ileotransverse colostomy was carried out. Convalescence was uneventful and the second-stage operation was carried out on Feb. 18. A firm oval tumour was found on the anterior and medial walls of the cæcum adjacent to the ileocæcal valve. The cæcum was extremely mobile owing to the possession of a long mesentery. There was also a malrotation of the midgut as the duodenum was confined to the right side of the abdomen, the third and

fourth parts being absent and the second part continuing on the right side into the jejunum. A right hemicolectomy was carried out.

PATHOLOGICAL REPORT (Dr. R. A. McInroy).—" The wall of the colon at the site of the tumour is the seat of islets of endometrial epithelium and stroma. No evidence of malignancy is seen in the tissues examined. The histological features are those of endometrioma of the cæcum." (*Figs.* 759, 760.)

FIG. 759.—Islets of endometrial epithelium and stroma at edge of endometrioma with intact covering mucosa of cæcum. (× 2·65.)

PROGRESS.—Convalescence was uneventful and the patient was discharged from hospital on March 6. When seen again on November 8 she was well and had had no recurrence of symptoms.

DISCUSSION

The striking feature in this case is the change of symptoms that followed the division of adhesions and freeing of the cæcum at the second operation. Cyclical bouts of comenstrual abdominal pain date from the first menstrual period following this operation and recurred with each period since then. Each attack was exactly similar in nature, except that in the last attack spontaneous resolution of symptoms did not occur. A similar sequence of events was present in the patient reported by Warmoes. At laparotomy for recurrent bouts of obstruction, the cæcum was found to be fixed in the pelvis by numerous adhesions. The cæcum was freed and a short-circuit ileocolostomy also carried out. Following this the patient had two attacks of abdominal pain, constipation, and passage of blood and mucus per rectum—each attack coinciding with a menstrual period. X-ray investigation disclosed a chronic cæcocolic intussusception which at the second operation was found to be due to an endometrioma of the cæcum. We feel that adhesiotomy was a major factor in the pathogenesis of intussusception in both these cases.

The congenital malrotation of the midgut found in the case described above must also have played an important role in allowing a chronic and recurrent intussusception of the cæcum to take place. It is not unusual in such congenital deformities for the hepatic flexure to be absent and for the cæcum and ascending and transverse portions of the colon to traverse obliquely across the abdomen to a normally situated splenic flexure. In such instances the cæcum is usually unduly mobile, and such mobility probably accounts for an intussusception, if it occurs, to be of a mild or subacute nature. This opinion receives support from cases published by White and Dennison (1952), who in a review of intussusception in children found that in cases with a mobile colon reduction was easily carried out and the bowel remained viable even after long duration of symptoms.

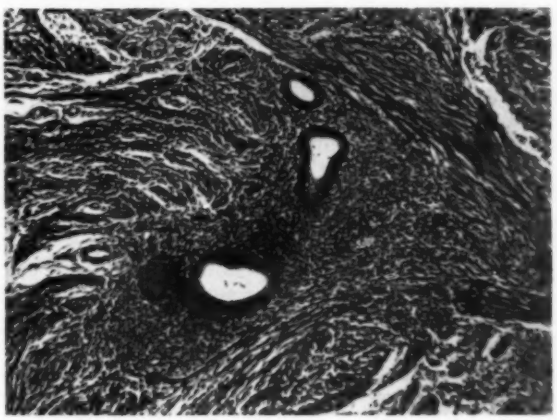

FIG. 760—Showing detail of endometrial epithelium and stroma in wall of cæcum. (× 47.)

Beaven (1929) also states that when an intussusception occurs, a long mesentery is the most important factor determining the chronicity of the lesion, since mesenteric traction does not occur or is very mild and thus the blood-supply of the bowel is not interfered with.

DEGREE OF OBSTRUCTION.—Intestinal obstruction was minimal in our case, as also in the cases reported by Warmoes (1951) and Cuningham and Smith (1948). In 11 adult cases of colo-colic intussusception due to carcinoma of colon, reported by Teasdale (1953), only 1 case presented with acute intestinal obstruction. It should be stressed again in this connexion that obstruction is not caused by the intussusception itself but by the œdema and congestion of the bowel wall resulting from traction on the mesentery. If the mesentery is long then a subacute intussusception will result and obstruction will be minimal or absent altogether.

Diagnosis.—The frequency of accurate diagnosis in intestinal endometriosis varies with the threshold of suspicion, and the single most important feature in these cases is periodicity of symptoms of intestinal obstruction which are associated with the menstrual cycle and the onset of menstruation. The usual triad of symptoms are cramping abdominal pain, abdominal distension, and constipation. (McGuff, 1948; McGuff, Dockerty, Waugh, and Randall, 1948.) The periodicity of abdominal pain in our case was well marked, but the regular bowel motions despite a nine days' history of colicky pain was misleading. The associated finding of a mass in the left iliac fossa led to a diagnosis of twisted ovarian cyst. It is interesting to note in this connexion that a similar diagnosis was made in the case of intussusception due to an endometrioma of the ileum reported by Cuningham and Smith (1948). The percentage of correct pre-operative diagnosis in any type of

endometriosis is low (Sinclair, 1952—33 per cent; and Kelly and Schlademan, 1949—14·5 per cent).

Aetiology.—The aetiology of external endometriosis has been well reviewed by Gardner, Greene, and Brooks (1953). These authors presented some interesting cases in support of the theory of cœlomic metaplasia. They were able to trace a gradual transition from endometrium to tubal secretory cells in a case of endometriosis of the Fallopian tubes and a similar metaplasia in a case of endometriosis of the appendix. They produce sound evidence for the concept of metaplasia from a review of the literature, but conclude that no simple theory of histogenesis can account for all cases. On the other hand Javert states that cœlomic metaplasia has no place in his composite theory of the aetiology of endometriosis. He postulates direct extension of endometriosis and of viable endometrial cells from the fimbriated ends of the tubes and their implantation on peritoneum and adjacent organs. Lymphatic and hæmatogenous metastases would then account for the distant foci. Sampson's implantation theory has gradually been discarded owing to the rarity of occurrence of retrograde menstruation and the realization that the endometrium cast off in menstruation is in reality a slough. However, cast-off menstrual fluid has recently been grown in tissue culture (Keital and Stein, 1951, quoted by Gardner and others, 1953) and should this work be confirmed, it would be strong evidence in support of Sampson's theory. In conclusion, external endometriosis may be due to cœlomic metaplasia or implantation of viable endometrial cells with extension by lymphatic and venous metastases. Implantation of cast-off menstrual endometrium may possibly account for some cases should conclusive evidence be forthcoming that such cells are viable.

Pathology.—Endometriosis is the only common condition in which there occurs invasion of one tissue by another normal tissue of the same host. It is difficult to assign to it a definite place in the pathological gallery, but this must be somewhere between benign and malignant conditions (Macleod, 1946). The invasiveness of this lesion and the possibility of venous and lymphatic metastases are all characters of malignancy. However, normal endometrium has the same vigorous growth and all areas of endometriosis are under the rigorous functional control of the ovary. These are characters more in keeping with a benign lesion.

There are two major types of intestinal endometriosis—the superficial and the deep. In the superficial type the lesion is mainly serosal and diffuse and symptoms are produced by the formation of adhesions. Obstruction occurs owing to kinking and angulation of the bowel at the site of these adhesions. The deep lesion is situated in the submucosa or muscle layer and is usually well localized, with formation of an endometrioma. Obstruction is caused by projection of the endometrioma into the lumen of the gut. The serosal lesion is usually found in the ileum, whilst endometriomata are commonest in the sigmoid.

The adhesions in this condition are typically dense and thick since they consist of areas of endometriosis. During their separation no natural plane of cleavage is found and there is always a danger of opening into the lumen of the gut when operating on these cases.

Treatment.—It is generally agreed that in young patients with intestinal endometriosis resection of the intestinal lesion together with an attempt at conservation of ovarian function is indicated whilst in older patients castration by oöphorectomy and conservative measures for the intestinal lesion should be carried out. (Hepburn and Randall, quoted by Strode and Strode, 1950; Macleod, 1946; McGuff and others, 1948). Others, however (Catell, Counsellor, Pemburton, quoted by Strode and Strode, 1950; Owen and Stone, 1949; Strode and Strode, 1950), state that castration is always necessary, as the disease will progress until this is done, and they feel that bowel resection is rarely indicated. It should be pointed out that these latter authors were mainly dealing with cases of sigmoidal endometriosis with extensive pelvic adhesions. In these cases resection is hazardous and in any case castration is indicated because of the diffuse nature of the disease process. It has been repeatedly observed that relief of intestinal obstruction due to infiltrating sigmoidal endometriosis occurs within 48 hours of withdrawal of the source of hormonal stimulation of the lesion (Benz, Dockerty, and Dixon, 1952; Owen and Stone, 1949). Thus in these cases castration without bowel resection is frequently curative. However, this is not always so and even protagonists of castration report cases which had to return following this procedure for bowel resection to be carried out, owing to persistence of symptoms (Strode and Strode, 1950). Just as castration is not effective in all cases, so obstructive symptoms from intestinal endometriomata may continue long after the menopause. Colcock and Lamphier (1950) were able to find reports of 6 cases with obstructive episodes long after the menopause, and reported another 2 cases of their own over the age of 65.

Another feature in favour of resection is a solitary lesion with minimal or absent pelvic endometriosis. The occurrence of intussusception should be an absolute indication for resection, whether this is done at one stage or after a preliminary short-circuit. Oöphorectomy alone cannot be relied on to produce complete regression of the associated fibrosis in an endometrioma, and if this remains there will be a tendency for the intussusception to recur. In these cases of solitary intestinal endometriosis the differentiation from carcinoma may only be possible by frozen section and many of these lesions are resected under the mistaken diagnosis of carcinoma. Frozen section is of definite value in these cases, as once the diagnosis is established a more limited resection than that necessary in carcinoma can be carried out. Finally it should be pointed out that carcinoma of the colon and pelvic endometriosis may coexist, and in these cases open inspection of the lesion and frozen section are necessary in order to arrive at the correct diagnosis and line of treatment (Hawthorne, Kimbrough, and Davis, 1951).

In our case a mistaken diagnosis of carcinoma of the cæcum was made. However, the treatment that was carried out in this case was amply supported when all the available factors were reviewed, especially the localized nature of the intestinal lesion and the occurrence of intussusception.

We would like to thank Mr. Norman Tanner for his interest and advice in the preparation of this paper. We are also indebted to Dr. R. A. McInroy for the photomicrographs and the description of the microscopical findings of the case.

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LYMPHOSARCOMA OF THE SMALL INTESTINE

WITH SPECIAL REFERENCE TO PERFORATING TUMOURS

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ALTHOUGH several hundred cases of primary lymphosarcoma of the small bowel have now been described, it is an uncommon condition seldom encountered by the individual surgeon. Free perforation of such a lesion into the peritoneal cavity is generally considered to be a rarity (Whitaker and Fisher, 1934; Lewis, 1939; Chont, 1941; Frank, Miller, and Bell, 1942; Poer, 1948; Hindmarsh, 1951; Bradmore and Scorer, 1953), fewer than thirty such cases having been recorded in the literature.

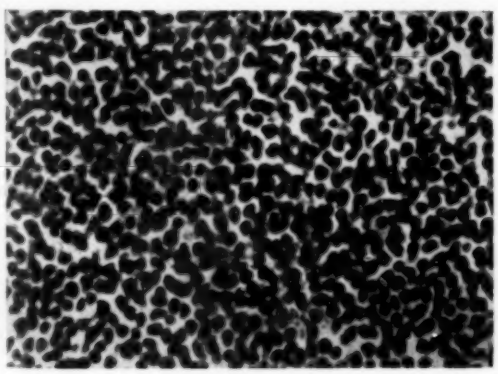

FIG. 761.—Small-cell lymphosarcoma. The cells are closely packed and rounded, with a large nucleus and scanty cytoplasm. H. and E. (× 330.)

This report describes a further 13 cases of perforating lymphosarcoma of the small bowel, and it seems probable that this is not such an unusual complication as the published records might suggest.

Material.—Thirty-seven primary sarcomata of the gastro-intestinal tract, 17 of which involved the small bowel, are recorded among the surgical specimens and necropsies of the Pathology Department of the Western Infirmary, Glasgow, in the 8-year period 1946–53.

The general term 'lymphosarcoma' is used here to include both true lymphosarcoma and reticulosarcoma. The first is composed of small round cells, with scanty cytoplasm and a moderately large nucleus, resembling lymphoblasts, prolymphocytes, and lymphocytes (*Fig.* 761). In the second the cells are mainly larger, of more stellate form, with pale cytoplasm, and a larger, sometimes convoluted, vesicular nucleus, often containing a nucleolus, and resembling more closely reticulum cells (*see Fig.* 770).

Incidence.—The incidence and sites of the various types of sarcomata are given in *Table I*, together with the number of adenocarcinomata observed over the same period for comparison. Lymphosarcoma occurred more frequently in the small bowel than in the large bowel, the commonest site being the ileum, as found also by Cheever (1932), Ullman and Abeshouse (1932), Cameron (1938), Frank, Miller, and Bell (1942), Poer (1948), and Faulkner and Dockerty (1952). For the whole gastro-intestinal tract the descending order of frequency is ileum, stomach, jejunum, and cæcum.

Eight of the 17 cases of small-bowel lymphosarcoma perforated. Details of these cases are given

in the appendix, together with 5 additional recent perforating cases from institutions outwith our routine pathological service.

Table I.—Distribution and Incidence of Primary Sarcomata and Adenocarcinomata of the Gastro-intestinal Tract observed in the 8-year Period 1946–1953

	Stomach	Duodenum	Jejunum	Ileum	Cæcum and Ascending Colon	Descending Colon	Rectum	Total
Lymphosarcoma	3[a]	1[b]	2[c]	4[d]	2	1	1	14
Reticulosarcoma	4	1[e]	4[a, c]	5	2	—	2	18
Leiomyosarcoma	1	—	1	—	—	1	—	3
Fibrosarcoma and neurosarcoma	—	—	—	2[f] (1 of each)	—	—	—	2
Adenocarcinoma	220	2	3	3	86	266	318	898

[a], additional involvement of duodenum in 1 case; [b], additional involvement of large bowel in 1 case
[c], additional involvement of ileum in 1 case; [d], additional involvement of large bowel and rectum in 1 case
[e], additional involvement of jejunum and ileum in 1 case; [f], the case of fibrosarcoma perforated

Age and Sex.—The average age of the 17 cases of small-bowel lymphosarcoma was 52·4 years (*Table II*). This disease is said to be not uncommon in children, but such cases are automatically excluded from this series, the minimum age for admission to this hospital being 14 years.

Table II.—Age Distribution of 17 Cases of Lymphosarcoma of the Small Intestine

Decade	3	4	5	6	7	8
No. of cases	1	4	1	4	5	2

Males are affected approximately two-and-a-half times more frequently than females, the figures here being 12 men and 5 women. This ratio was the same for tumours of both cell types, although Faulkner and Dockerty (1952) found that the small-cell lymphosarcoma occurred five times more frequently in men.

Pathology.—The gross lesions of lymphosarcoma of the small intestine are generally described as being either polypoid or annular, although the two forms may occur together.

The less common polypoid form is frequently multiple and presents as a fairly localized outgrowth of variable size projecting into the lumen of the gut, commonly in the ileocæcal region. The surface may show ulceration and fungation, and the growth may give rise to intussusception, intestinal hæmorrhage, or volvulus. Symptoms of chronic intestinal obstruction are frequently produced, sometimes with hypertrophy and dilatation of the proximal bowel.

The commoner annular form is usually single and affects a variable length of bowel, a large segment occasionally being converted into a firm, rigid 'hose' by diffuse infiltration. The growth commences in hyperplastic lymphoid tissue in the submucosa and diffuses widely through the submucosal layer, in which the great bulk of the tumour generally lies. Later there is infiltration and destruction of the mucosa and eventually ulceration occurs, but the superficial mucosal cells may persist remarkably late in the disease as may also the muscularis mucosa. Eventually the neoplasm infiltrates and destroys the muscle layers and reaches the subserosa, and the greatly thickened gut wall may become adherent to other loops or neighbouring viscera. As in the polypoid form, the tumour margin is generally fairly sharply outlined, but in some instances hyperplastic submucosal lymphoid tissue extends in a diminishing degree from the edge of the neoplastic mass.

The bulky submucosal mass narrows the bowel, but superficial ulceration and the absence of fibrosis usually prevents complete occlusion of the lumen. Ullman and Abeshouse (1932) emphasized the tendency to aneurysmal dilatation of the involved bowel due to the destruction of the muscle coats or the submucosal nerve plexus, and producing obstruction by stasis or kinking of the gut.

A third type of lesion, an ulcerative form, has received little attention; it consists of one or more ulcers involving the whole or a large part of the circumference of the gut with no gross tumour mass. While occasionally undermined, the ulcer edges are usually slightly rolled and thickened, owing to submucosal inflammatory œdema rather than to neoplastic infiltration. A thin layer of tumour cells forms the ulcer floor, and the progressive penetration of this layer deepens the ulcer and thins the gut wall (*Fig.* 762). In the more necrotizing forms of the neoplasm the amount of surviving tumour tissue is remarkably slight and may be missed histologically in the accompanying inflammatory infiltrate, especially should the nature of the lesion not be suspected. The subserosal layer is reached by direct extension and rapid ulceration of the growth with destruction of the muscle layer, but occasionally there may be more massive growth and infiltration between the mucosa, muscle, and serous coat, through which necrosis and ulceration may lead to the formation of a track from the lumen to the subserosa (*Fig.* 763). The ulcerative necrotizing form of growth is prone to perforate into the peritoneal cavity (*Figs.* 764–767) and the duration of symptoms is generally short.

In the present 17 cases 2 of the growths were polypoid, 9 predominantly annular, and 6 of the

ulcerative type. The lesions were multiple in the small bowel in 9 of the cases, with involvement of the large bowel also in 2.

Perforation occurred in 4 annular and 4 ulcerative lesions, 6 of the growths being reticulosarcomata and 2 lymphosarcomata. In 5 instances the perforation occurred in the jejunum, and in the remaining 3 in the ileum.

Early metastases to the mesenteric lymph-nodes is the rule in intestinal lymphosarcoma and had occurred in at least 13 of this series when the diagnosis was first made.

Symptomatology.—The modes of presentation are given in *Table III*. The duration of symptoms was generally short and dated from the onset of abdominal pain or vomiting, but previous anorexia and weight loss had been noticed by 10 patients.

Recurring attacks of abdominal pain were experienced by 10 patients. In 7 the pain was mid-abdominal and of a colicky nature, often following food, and was occasionally relieved by a semi-fluid diet. In 3 patients the pain rapidly intensified, with the development of complete intestinal obstruction two to five weeks after the first attack of colicky pain. In contrast 3 patients complained of constant

FIG. 762.—*Case* 6. Ulcerative lymphosarcoma of jejunum. This early ulcer shows extension to the muscle, some inflammatory œdema of the edges and serosa, but no gross tumour. A similar neighbouring ulcer perforated. Mallory's trichrome. (× 6·5.)

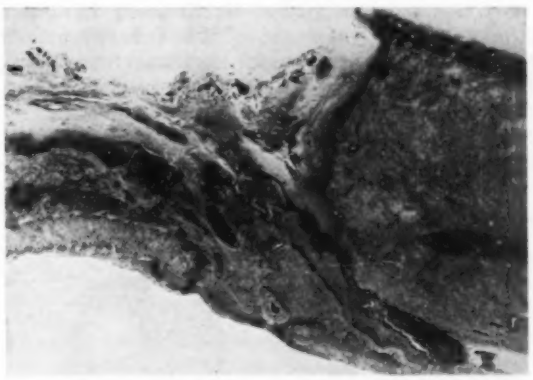

FIG. 763.—Non-perforating ulcerative lymphosarcoma of the duodenum. At one point the necrotizing tumour has penetrated the muscle and formed a sinus connecting the ulcer floor and the subserosal layer. H. and E. (× 7.)

FIG. 764.—*Case* 8. Necrotizing ulcerative reticulosarcoma of jejunum showing perforation, no gross tumour, and inflammatory œdematous thickening of the ulcer margins.

FIG. 765.—*Case* 9. Necrotizing ulcerative lymphosarcoma of ileum with perforation. The thickening of the ulcer edges is due to inflammatory œdema only.

Table III.—MODE OF PRESENTATION OF 17 CASES OF SMALL-BOWEL LYMPHOSARCOMA

Mode of Presentation	*No. of Cases*
Acute intestinal obstruction	3
Abdominal emergencies with peritonitis	8
Medical emergencies { diarrhœa 1	2
Medical emergencies { melæna 1	2
Miscellaneous alimentary symptoms requiring investigation	4

boring abdominal pain. In 2 the pain was in the epigastrium and made worse by food, but barium meals showed no lesion. At exploratory laparotomy one was found to have a necrotic jejunal tumour on the point of perforation, while perforation of an upper jejunal tumour occurred in another, one month after the onset of pain. Perforation of an ileal sarcoma occurred in the third patient following recurrent pain in the right inguinal fossa for one month.

Constipation was present to a varying degree in 9 cases, usually in association with colicky abdominal pain, and later, vomiting. One acutely ill patient

FIG. 766.—*Case* 10. Necrotizing, perforating reticulosarcoma of ileum showing the absence of gross tumour and the marked inflammatory œdema of the submucosa about the ulcer. H. and E. (× 7.)

was admitted to a medical ward on account of colic and diarrhœa of six weeks' duration, and, at necropsy, ulcerating tumours of the duodenum and colon were found.

Only 3 cases had frank melæna, but in 2 of these it was the presenting symptom. Multiple tumours of the ileum and colon with widespread metastases were seen in one at laparotomy; the other was admitted in a collapsed state to a medical ward. After transfusion, a barium meal and enema were negative; melæna recurred and she was found to have an ileal sarcoma at necropsy.

Signs.—Recent weight loss was obvious in 12 cases. Seven showed some degree of abdominal distension, which was marked in the 3 presenting with acute intestinal obstruction, and peristalsis was visible in 1 case. Various degrees of localized tenderness and guarding were present in the 8 perforating cases (*see* Case Reports). A palpable mass was found in only 3 instances and in 2 proved to be ileal sarcoma. The third was a polypoid, ileal growth which had produced an ileocæcal intussusception. In over 50 per cent of recorded cases in some series a palpable mass has been noted and the low incidence in this series may be related to the high proportion of cases admitted as acute surgical emergencies with other masking abdominal signs.

Radiology.—Barium meals and enemas were done in the 4 cases admitted for investigation. In only 1 case, a sarcoma of the terminal ileum, was a positive result obtained, and this was thought radiologically to indicate carcinoma of the cæcum. Barium meals and enemas had recently been done in 4 of the 12 acute emergency admissions, with negative findings. Thus 8 of the 17 patients had barium investigations, all but one of which proved negative. In no case was a barium follow-through of the small intestine then carried out and, in obstructive cases, injection of barium via a Miller-Abbott tube had not been tried.

Treatment.—

Non-perforating Cases (9 cases).—Three died shortly after admission without surgical intervention and 2 others proved inoperable at laparotomy.

FIG. 767.—*Case* 2. Necrotizing, perforating reticulosarcoma of jejunum with scanty tumour cells in the inflammatory infiltrate about the ulcer. Mallory's trichrome. (× 47.)

Resection of gut, with hope of cure, was performed in the remaining 4 patients (enterectomy, 2; right hemicolectomy for lesions of the terminal ileum, 2). These 2 latter and 1 of the former have survived for five or more years.

Perforating Cases (8 cases).—Two of these died without operation. Drainage of the peritoneal cavity alone was carried out in other 2 cases, both dying post-operatively, and only 1 had a primary resection and anastomosis. On account of the poor condition, the perforation was oversewn, with no resection, in the remaining 3 patients; one died four days later, resection was performed in a second after a two-week interval, and the third was found to be inoperable three months after closure of the perforation.

All patients, except 4 who died in the immediate post-operative period, received radiotherapy.

Survival.—Five patients died without any operation shortly after admission to hospital, and 4 others died in the immediate post-operative period, only 1 following gut resection. The 3 patients found to be inoperable died two, four, and eighteen months later. Resection of gut was performed in the remaining 5 cases, and 2 of these died six months and five years afterwards of the disease. The remaining 3 cases are alive and show no evidence of the disease five to seven years after operation. One, a man aged 50, had a right hemicolectomy five years ago for a polypoid lymphosarcoma of the terminal ileum which produced intussusception. Another man, aged 31, also had a right hemicolectomy 7 years ago for an annular reticulosarcoma in the terminal ileum (*Figs.* 768–770). The third, a male aged 57, has survived seven years following gut resection for an annular ileal lymphosarcoma which produced partial stenosis and obstruction.

None of the perforating cases has survived.

DISCUSSION

The high incidence (47 per cent) of perforations in this small series of 17 cases of lymphosarcoma of the small bowel is remarkable. Few such cases are reported in the literature, this complication generally being regarded as a rarity. In keeping with lymphoid tumours in general, lymphosarcoma of the small bowel now appears to be observed more frequently than formerly (Cappell, 1954) and this neoplasm should therefore be kept in mind in all perforating lesions of the small intestine, even in the absence of obvious tumour. The essential cause of some of these perforations is often not recognized, particularly when no tumour is palpable. Lymph-node involvement may not be visible to the naked eye at first, although massive infiltration may rapidly develop later, and the lesions are frequently attributed to a foreign body, inflammation, or abdominal injury. It is essential therefore that tissue be examined microscopically as otherwise tumour cannot be excluded. Even then the diagnosis is not always easy as the scanty tumour cells may be largely obscured by the secondary inflammatory reaction.

The diagnostic difficulties of this disease are well recognized and are exemplified in these cases. The onset was usually insidious, with few definite signs or symptoms. The history was often extremely short and, indeed, perforation was occasionally the first evidence of the disease. Suspicion may be aroused by recent weight loss and recurring attacks of mid-abdominal colic, frequently following meals. The pain may, however, be constant in nature rather than colicky and the 3 patients with this type of pain soon perforated. With such symptoms or with unexplained melæna, if radiology fails to demonstrate a lesion in the stomach or colon, attention should be focused on the small bowel. In the absence of obstruction a careful barium follow-through of the

FIG. 768.—Non-perforating, annular reticulosarcoma of the terminal ileum, with thick walls, ulcerated surface, and narrowing of the lumen. This 31-year-old male is alive and well 5½ years following a right hemicolectomy.

FIG. 769.—Ileocæcal lymph-node from *Fig.* 768, showing many large hyperplastic Flemming's centres and replacement of the normal architecture in one area by a mass of proliferating reticulum cells. The appearances suggest that the lesion is multifocal in origin. H. and E. (× 10.)

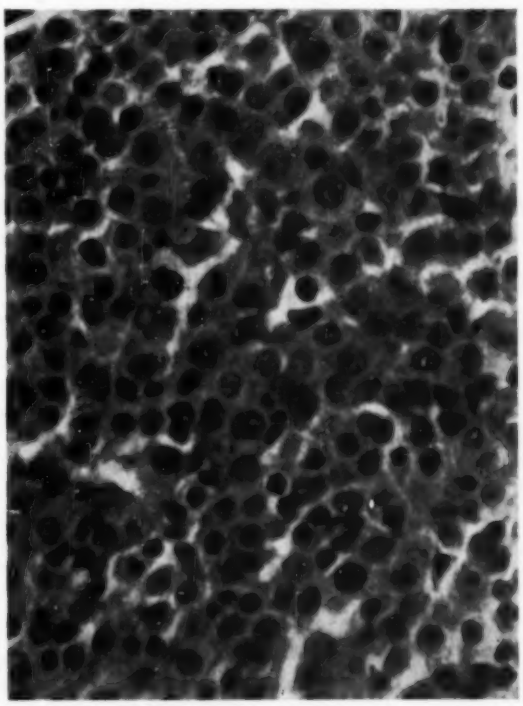

FIG. 770.—Reticulosarcoma. This cellular detail is representative of the main tumour (*Fig.* 768) and of the hyperplastic Flemming's centres and mass in *Fig.* 769. H. and E. (× 460.)

small bowel will frequently reveal the lesion (Cameron, 1938; Mayo, 1940; Craig, 1941; Good and MacCartney, 1942; Weber and Kirklin, 1942; Swenson, 1943; Hamilton, Kennedy, and Herault, 1944; Fraser, 1945). In the presence of obstruction special radiological techniques, using the Miller-Abbott tube, have been recommended by Simpson-Smith (1939), Frank, Miller, and Bell (1942), Hamilton and others (1944), and Fraser (1945).

In agreement with Winkelstein and Levy (1943) and Marcuse and Stout (1950), no significant association between cell type and clinical signs or symptoms was observed. In this series the average length of history did not differ materially in each cell variety, but the reticulosarcomata were often ulcerative lesions (4), occurred mainly in the proximal bowel (5), and perforated three times more frequently than lymphosarcoma. A better prognosis was ascribed to small-cell lymphosarcoma by McSwain and Beal (1944): 2 of the 3 survivors in this series had this type of growth.

The prognosis in this disease is indeed poor. The average duration of symptoms of the patients who died of the disease, excluding one who lived for five years after operation, was seven months, and the average survival of the same group after diagnosis was only two months. In many instances this poor survival could be correlated with the advanced stage of this disease when first seen or the poor condition of the patient at operation.

However, successful salvage of some cases is possible. Of the 5 patients surviving gut resection 3 are alive and well five to seven years after operation. Such cases are a stimulus to earlier diagnosis and treatment.

CASE REPORTS

Details of 13 cases of perforating lymphosarcoma of the small bowel are given below. Cases 1–8 were admitted to the Western Infirmary, Glasgow, in the period 1946–53.

Case 1.—Male, aged 62. Pain in right iliac fossa for one month, continuous for past two days, nausea and slight weight loss, bowels and stools normal. He was acutely ill, with tenderness and guarding over the R.I.F., but no palpable mass, and tender to the right on rectal examination. T. 98°, P. 94/min. His condition deteriorated, although given streptomycin, and at operation, four days after admission, a large pelvic abscess was found and drained. A small-bowel fistula developed and he died three weeks following operation. Necropsy: The distal ileum and the omentum were involved in a large purulent mass containing necrotic tumour. Histology: Perforated reticulosarcoma of the ileum.

Case 2.—Male, aged 74. Frequency, dysuria, suprapubic pain, and weakness for several days only; frail and emaciated. T. 96°, P. 100/min. The suprapubic region was distended and tender, but the bladder was empty. Death occurred within one hour of admission. Necropsy: Peritonitis. Seven ulcers involved the jejunum and terminal ileum. The ulcers were transverse, with slightly thickened margins but there was no gross tumour. Perforation of the most proximal jejunal ulcer had occurred (*see Fig.* 767). Histology: Necrotizing perforated reticulosarcoma of the small bowel with evidence of superadded tuberculous infection of some of the ulcers.

Case 3.—Male, aged 62. Anorexia for ten months, increasing constipation for six months, with vomiting and abdominal discomfort after food for two months, slight weight loss and weakness. T. 100°, P. 88/min. The abdomen was tender, mainly in the left upper quadrant, with no guarding and no palpable tumour. A barium meal showed no lesion in the stomach or duodenum, but many rounded opacities were seen in the chest radiologically. His condition deteriorated rapidly, with increasing pyrexia, and he died six days after admission. Necropsy: Peritonitis. Throughout the duodenum there were numerous small white submucosal nodules. The jejunum was dilated and hypertrophied proximal to two annular, grossly ulcerated tumours, with mesenteric involvement and perforation of the distal ulcer. Both lungs contained numerous spherical metastatic tumours. Histology: Reticulosarcoma of jejunum and duodenum with pulmonary metastases.

Case 4.—Female, aged 56. Listlessness and weakness for some months, with recurrent lower abdominal pain and vomiting for two weeks. No constipation or weight loss. The pain became severe and generalized on the day of admission, with frequency and dysuria. There was some abdominal distension, generalized tenderness and guarding, maximal in the epigastrium, but no abnormal palpable mass. T. 101°, P. 125/min.

At operation, peritonitis and a large ileal tumour adherent to other organs, were found. Resection was not possible and the abdomen was drained; death occurred three days later. Necropsy: Peritonitis. Eighteen in. from the ileocæcal valve there was a necrotic perforated ileal mass adherent to other bowel loops, bladder, and uterus. No tumour was found in the lymph-nodes or elsewhere. Histology: Perforated lymphosarcoma of the ileum.

Case 5.—Female, aged 35. Recurrent colicky epigastric pain for five months with poor general health and some weight loss. One week before admission a palpable tender mass was found to the left of the umbilicus, but a barium meal showed no lesion in the stomach or duodenum. The pain became severe and constant in the epigastrium, with vomiting on the admission day. Tenderness and guarding were maximal over the mass and there was tenderness on rectal examination. T. 101°, P. 140/min.

At operation peritonitis and an ileal mass with perforation of one of several adjacent ileal ulcers were found. Owing to the patient's condition the perforation was biopsied and closed and the affected bowel short-circuited. Two months later, following radiotherapy, the growth was found to be inoperable. Further radiotherapy was given but the patient died at home with widespread dissemination (abdomen, skin, liver, and spleen) seven months after the first operation. Histology: Reticulosarcoma.

Case 6.—Male, aged 64. Anorexia, weight loss, and vague upper abdominal pain after meals, not relieved by alkalis, for six months. A barium meal four months before admission showed no lesion. The patient was admitted with acute epigastric pain, generalized abdominal tenderness, and guarding. T. 97°, P. 100/min.

At operation peritonitis and two jejunal ulcers, one of which had perforated, were found. Owing to the patient's poor condition the perforation was closed and the ulcerated area short-circuited. Death occurred four days later. Necropsy: Peritonitis. Five transverse jejunal ulcers were present with no gross tumour, the most proximal ulcer having perforated. No other tumour involvement was found, but there was a purulent pneumonic consolidation of two lobes. Histology: Necrotizing ulcerative lymphosarcoma of the jejunum (*see Fig.* 762).

Case 7.—Male, aged 31. Five days' diarrhœa followed by sudden onset of severe central abdominal pain with generalized tenderness and guarding, maximal to the right of the umbilicus. T. 98°, P. 90/min. No previous symptoms.

At operation peritonitis was found and a perforated jejunal ulcer was biopsied and oversewn. Two weeks later 3 ft. of jejunum were resected. This contained an ulcerated annular tumour mass, narrowing the lumen, with involvement of the adjacent mesenteric lymph-nodes. Histology: Reticulosarcoma. Radiotherapy was commenced, but the patient died seven weeks after the first operation. Necropsy: Acute massive necrosis of the liver. No tumour was found.

Case 8.—Male, aged 31. Recurring pain in the right iliac fossa, not related to food, for one month, with normal bowel habit and no weight loss. Admitted with acute, severe, right lower abdominal pain, tenderness, and guarding in the R.I.F. T. 100°, P. 90/min.

At operation peritonitis was found, and a length of jejunum containing a perforated ulcerative lesion with no gross tumour was resected (*see Fig.* 764). Histology: Reticulosarcoma of jejunum and regional lymph-nodes. Following radiotherapy he remained well for four years 10 months, when he developed diarrhœa and anorexia with intermittent pyrexia and a leucocytosis (W.B.C. 22,000/c.mm.; eosinophils 80 per cent) but no lymphadenopathy. Further radiotherapy was given, but he died fifty-nine months after his operation. Necropsy: Obliterative pericarditis and enlarged lymph-nodes in the porta hepatis only. Histology: Reticulosarcoma.

Case 9.—Male, aged 71. Previously well, he was admitted to the Lewis Hospital, Stornoway, with constant lower abdominal pain of two days' duration with generalized tenderness and guarding, maximal in the R.I.F.

At operation peritonitis was found and a length of terminal ileum which contained a perforated ulcerative lesion 18 in. from the ileocæcal valve was resected (*see Fig.* 765). Histology: Perforated lymphosarcoma of ileum. The patient died at home four months later of 'pneumonia'.

Case 10.—Female, aged 70. Admitted to hospital for investigation of intermittent gnawing upper abdominal pain of eighteen months' duration, not related to food or relieved by alkalis; marked weight loss, anorexia (eight months) and vomiting (one month). Eight months previously a barium meal had been reported negative elsewhere. A further barium meal, a pyelogram, and a chest film were normal; occult blood and W.R. negative. Whilst in hospital she developed a tender, palpable, left abdominal mass, with some distension and pyrexia. At laparotomy no peritonitis was seen, but there was an encircling lesion in an ileal loop with massive enlargement of mesenteric and para-aortic lymph-nodes. A nearby smaller ileal lesion was resected and found to be a perforated, necrotizing reticulosarcoma (*see Fig.* 766), the perforation presumably having occurred in removal. Death occurred five days after operation; necropsy was not allowed.

Case 11.—Female, aged 52. Admitted to the Royal Infirmary, Greenock, as an acute surgical emergency.

At operation peritonitis was found and two perforated ulcers of the lower ileum, with no gross tumour, were oversewn. The post-operative course was poor, a fæcal fistula developed, and she died four weeks after operation. Necropsy: the two ileal areas now showed neoplastic infiltration of the gut, one lesion being adherent to the wound. White, firm tumour replaced some of the mesenteric, para-aortic, left cervical, mediastinal, and right inguinal lymph-nodes, and there was caseous tuberculosis of the right kidney. Histology: Reticulosarcoma.

Case 12.—Male, aged 52. Epigastric pain and tenderness, partly relieved by alkalis but not affected by food, had been present for several years, but worsened in the past three months. He also complained of some recent anorexia, nausea, and weight loss. On the day of admission the pain became severe and constant and the abdomen was tender and rigid: T. 99°, P. 68/min: no lymphadenopathy. Laparotomy: peritonitis and several friable, œdematous, thinned small-bowel segments were seen, the most distal of which had perforated in the terminal ileum. The perforation was oversewn. A subphrenic abscess developed and was drained, but he died two weeks after laparotomy. Necropsy: multiple, thinned, ulcerative lesions were found in the ileum, with others in the jejunum and stomach. Histology: Ulcerative reticulosarcoma.

Case 13.—Male, aged 74. Alternating constipation and diarrhœa, with anorexia and marked weight loss, noticed for twelve months. Two days before admission he developed severe abdominal pain and slight diarrhœa: generalized abdominal rigidity and tenderness were maximal in the L.I.F.: T. 104°, P. 105/min. Operation: resection of a jejunal loop containing a perforated tumour. This ulcerated, white growth encircled two thirds of the bowel circumference and extended into the adjacent mesentery. Histology: Reticulosarcoma of jejunum and mesenteric lymph-nodes. Alive and well six weeks after operation.

SUMMARY

1. Details are given of the incidence, age, sex, and symptomatology of 17 cases of lymphosarcoma of the small bowel admitted to the Western Infirmary, Glasgow, in the 8-year period 1946–53.

2. The pathology of the disease is described and attention is drawn to the ulcerative, often necrotizing variety in which no tumour may be grossly visible.

3. The difficulties of diagnosis are emphasized.

4. Although considered to be a rarity in the literature, perforation occurred in 8 (47 per cent) of the 17 cases in the Western Infirmary series and 5 other recent perforating cases are described. Perforation may occasionally be the first evidence of the disease.

5. No significant association was noted between the cell-type variants and the clinical signs and symptoms. However, reticulosarcomata were more often ulcerative lesions, occurred mainly in the proximal bowel, and perforated three times more frequently than lymphosarcomata.

6. The prognosis in this disease is poor. However, of the 5 cases which were resectable 3 have survived for five to seven years and are at present apparently free of disease.

7. Of the 13 perforating tumours described, 10 were reticulosarcomata and 3 were lymphosarcomata; 7 of the lesions were of the annular type and 6 were ulcerative; the perforation occurred in the ileum in 7 and in the jejunum in 6; 9 males and 4 females were affected, the ages ranging from 31–74 years.

We wish to express our thanks to the physicians and surgeons of the Western Infirmary, Glasgow, for permission to publish clinical details of their cases; to Mr. E. N. Jamieson for the details of *Case* 9, Mr A. Lyall and Dr. J. Stewart for the details of *Case* 11; and Mr. G. Kerr for the photographs.

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POLYVINYL ALCOHOL SPONGE

AN INERT PLASTIC FOR USE AS A PROSTHESIS IN THE REPAIR OF LARGE HERNIAS

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IT is occasionally necessary to use some foreign material to reinforce or replace damaged tissues when repairing large herniæ, but the limitations of those in common use at present are well recognized. Foremost of these limitations, and common to all materials such as tantalum gauze, stainless steel mesh, nylon mesh, and polythene film, is failure to become united with surrounding living tissue, which is an undesirable quality in any foreign material used to replace abdominal wall. The ideal material would not have this deficiency and would also be chemically inert, biologically non-irritant, pliable, workable, and strong. Although such a substance has not yet been found, polyvinyl alcohol sponge, which was first described by Grindlay and Clagett (1949), does approach this ideal.

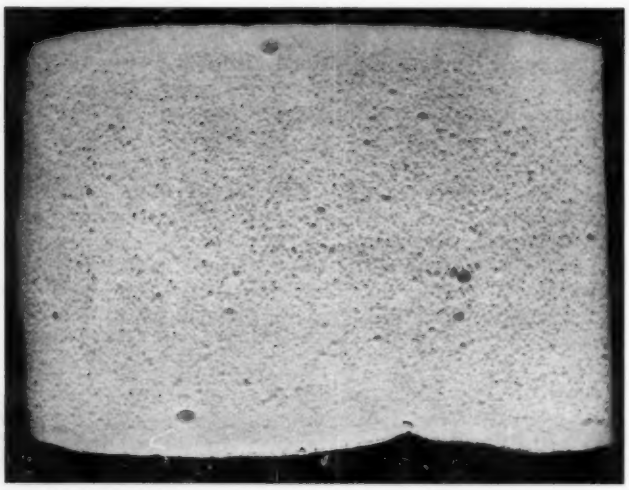

FIG. 771.—A slice of polyvinyl alcohol sponge, showing texture resembling cut surface of a slice of bread.

THE MATERIAL

Polyvinyl alcohol sponge is made by a special process in which the alcohol is foamed and then hardened with formaldehyde. Sponges of uniform texture and high quality are available commercially. These can be wetted and wrung out like sea sponge.

The pure sponge is white and its surface has the appearance of the cut surface of a slice of bread (*Fig.* 771). The texture and density of the sponge can be varied during manufacture—the denser sponges have great tensile strength. When dry the sponge is hard and rigid ; when moist it is resilient and soft. The dry sponge can be cut with a heavy knife, and moist sponge can be cut easily with a sharp knife or scissors.

Physically it is characterized by its great affinity for water—not only does the substance of the sponge become permeated with water and swollen, but the sponge will hold as large a volume of water as will a sea sponge.

Temperatures up to 120° C. have no effect on polyvinyl sponge, but after one hour at 160° C. it turns brown. When boiled in water for the first time there is slight shrinkage, but subsequent boilings do not cause further shrinkage. If the sponge is compressed whilst it is water heated above 95° C. and if the compression is maintained while the sponge is cooled to a temperature less than 95° C. the deformity caused by compression will remain. The deformity can be removed and the sponge restored to its original shape by heating it again in water above 95° C.

If stored dry the sponge keeps perfectly, but if left exposed to the air when moist, fungus and rust may infect the interstices and cause dark stains to appear.

Preparation for use in Surgery.—The polyvinyl sponge being used at present is made by the Ramer Chemical Co., Ltd., who supply it in slices of

varying size and thickness. It has been found that a thickness of 3 mm. or 4 mm. is most suitable. As received the sponge is dry and hard. Before use a slice is boiled for twenty minutes in sterile distilled water. A flat dish with a lid and sufficient water to cover the sponge to a depth of an inch have been found most suitable; the sponge should float freely without touching the vessel and thus not be deformed whilst being boiled. The vessel is allowed to cool before removal of the sponge, or cold sterile water added before lifting the sponge.

The boiled and cooled sponge is then wrung out, soaked in sterile isotonic saline, and wrung out again. It is now ready to be placed in the body.

EXPERIMENTAL INVESTIGATION

The efficacy of polyvinyl sponge in hernia repair was first tested in animals, and strong sound repairs were obtained in experimentally produced defects in the abdominal wall of dogs and rabbits. Tests of tensile strength were carried out (Schofield, Hallenbeck, Grindlay, and Baldes, 1954).

FIG. 772.—Photomicrograph of edge of sponge sutured to muscle. The fibrous tissue can be seen growing in continuity through the interstices of the sponge. (× 22·5.)

FIG. 773.—Photomicrograph of cellular fibrous tissue invading interstices of sponge with almost complete absence of foreign-body reaction. (× 45.)

It was found that the sponge needs to be carefully sutured into position, preferably sandwiched between two layers of tissue at the periphery. This encourages firm union at the edge of the prosthesis, which was found to be the weakest point in the repair. There should be no movement at the edges as the fine granulation tissue can be torn, and, if loose, the sponge will become encapsulated rather than incorporated in the tissue.

Granulation tissue invades the interstices of the sponge, which provides a semi-rigid framework. As the granulation tissue matures to adult fibrous tissue the repair becomes more solid, yet not rigid. There is almost complete absence of foreign-body reaction (*Figs.* 772, 773). This latter observation has been utilized by Schilling, Favata, and Radakovich (1953), who used small fragments of sponge inserted in the subcutaneous tissues of rabbits for the study of the maturation of the fibroblast.

In one of our animals the repair became infected, and when examined six months after the operation the sponge was found lying free in an abscess cavity containing sterile pus. No antibiotics had been used. The repair was sound and it was thought that the sponge had remained fixed for some time before the granulation tissue in its interstices had been digested by the enzymes in the pus. Nevertheless, infection is the greatest threat in the use of this, as in any other, foreign body implant.

It is not essential to have peritoneum deep to the sponge. In several animals it was placed in contact with the viscera and within a few days the peritoneum had covered the deep surface of the sponge and at no place was there any adhesion between coils of intestine or between omentum and sponge.

APPLICATION IN REPAIR OF LARGE HERNIÆ

Following the experimental work it was thought reasonable to use polyvinyl sponge in man.

The sponge is prepared for use as already described, and when ready is cut roughly to shape. The insert is sutured into position using non-absorbable sutures—fine silk or linen—at 0·5-cm. intervals. There should be just that tension necessary to distort the air spaces a little. This tension is easily obtained as, using sharp scissors, the sponge can be readily cut to the exact size required.

In all cases in man, so far, in which the sponge has been used it has been possible to close the peritoneum and, except once, the surface of the sponge has been covered by a layer of deep fascia, the fibrous tissue of the hernial sac having been found most useful in this respect. The need for this step was made clear after the sponge was used for the first time in a patient (*Case* 1).

If there is only paper-thin skin available to cover the polyvinyl sponge insert, when this is sutured over the sponge there is insufficient blood-supply to maintain its viability. Friction between it and the as yet uninvaded sponge leads to sloughing of the skin. There must be either an adequate layer of subcutaneous fat between the upper surface of the prosthesis and the skin, or else the sponge must be deep to a layer of fascia or aponeurosis.

Sepsis must be avoided. Careful skin preparation and exclusion of the skin edges with tetra towels should be observed. As an added precaution it is

usual to spray the insert with penicillin solution or dust with penicillin lactose powder. Meticulous hæmostasis and avoidance of drains is stressed.

As the sponge is elastic it can stretch so as to accommodate the strain of coughing without fear of the fixing sutures cutting out. As the granulation tissue matures to adult fibrous tissue the repair becomes more solid, but it will not stretch more than the sponge itself.

Patients have been kept in bed for 7–10 days following operation, but have all been encouraged to move about in bed as much as possible.

CASE REPORTS

Case 1.—Male, aged 69 years. There was a large midline epigastric incisional hernia, with a defect 10 cm. in diameter between the costal margin and rectus muscle. Two unsuccessful attempts at repair had been made. The coils of intestine could be seen beneath the paper-thin scar. At operation two layers of polyvinyl sponge were sutured to the edges of the defect and the scar tissue sutured back over the surface of the sponge. The thin skin sloughed, a low-grade infection was established in the sponge which had to be removed. The repair was a failure.

From this case the lesson was learnt that the sponge must be adequately buried. When only scarred skin is available it should be excised and a flap of healthy skin and subcutaneous tissue swung over to cover the prosthesis.

Case 2.—Male, aged 54 years. History of post-operative midline epigastric hernia with attempted repair using anterior rectus sheath overlap. There was a large incisional hernia with marked divarication of the recti. Size of neck of hernia 7·5 × 5 cm. At operation the old scar was excised, the hernial sac dissected out, preserving the remnants of the anterior rectus sheath. After excision of excess, the peritoneum was closed and a single layer of polyvinyl sponge sutured to the under surface of the edge of the rectus muscle. The remains of the anterior sheath were sutured over the sponge and the skin and subcutaneous tissues closed.

The post-operative course was uneventful and one year after operation there is no sign of recurrence of the hernia. The abdominal wall is a little lax at the site of the repair, probably owing to there being insufficient tension in the sponge at the time of operation.

Case 3.—Female, aged 42 years. This patient had noticed a swelling in the lower abdomen for three months. On examination there was a hard nodular mass involving the lower part of the right rectus muscle and extending towards the right iliac fossa. It was thought to be in the abdominal wall and a presumptive diagnosis of desmoid tumour was made. Removal of the rectus muscle was expected, and it was proposed to fill the gap with polyvinyl sponge.

At operation the mass was exposed through an oblique incision. The anterior rectus sheath was opened and a tumour found involving the rectus muscle, posterior rectus sheath, the internal and external oblique, and the transversus muscles as far out as the anterior superior iliac spine. The peritoneum and the right ovary and tube were also involved. The whole tumour mass together with the adherent viscera was resected. Peritoneum was closed with difficulty, and a muscular defect 10 × 8 cm. was bridged by a single piece of polyvinyl sponge 4 mm. thick. The anterior rectus sheath was sutured over the insert.

Convalescence was uneventful. Three months after operation there was a definite firmness in the repair, but nine months following operation the abdominal wall feels and looks normal. The patient is a schoolteacher and takes an active part in 'gym' and games with no symptoms.

Case 4.—Male, aged 54 years. An obese plethoric man suffering from chronic bronchitis was admitted with an irreducible left inguinoscrotal hernia. At operation there was marked deficiency of the posterior wall of the inguinal canal, the conjoint tendon being a mere fibro-fatty band. The posterior wall was reconstructed, using a 4-mm.-thick piece of polyvinyl sponge sutured to pubic spine, inguinal ligament, and internal oblique muscle. The lateral part of the sponge was divided and sutured around the cord to produce a new internal ring.

Ten months after operation there is a very sound repair with no evidence of recurrence of the hernia.

Cases 5–9.—Five other large inguinal herniæ have been repaired, using a slice of sponge to replace the posterior wall of the canal. In *Cases* 5–8 the patients were old, bronchitic, and all had large herniæ—three being of the sliding type. *Case* 9 was a younger man, aged 32, who had three previous attempts at repair of an inguinal hernia. He was admitted with an obstructed hernia and at operation to relieve this it was decided to use a plastic prosthesis to strengthen the deficient structures.

All these patients made good progress after operation and there has been no sign of recurrence from 9–12 months later.

Case 10.—Male, aged 46 years. After a left nephrectomy in 1938 this patient developed a large incisional hernia following infection in the wound. The hernia had been controlled by a belt, but in 1954 a small discrete lump appeared just below and medial to the anterior superior iliac spine at the lower limit of the hernia. This subsequently proved to be an abscess. At operation the old scar was excised and a very large incisional hernia extending from the erector spinæ muscles to midway between symphisis pubis and anterior superior iliac spine was displayed. There was very little muscluar or tendinous attachment to the iliac crest, and the hernia sac was covered only by overstretched scar tissue. This layer was dissected free from peritoneum and the size of the sac reduced. The muscular defect was roughly elliptical, 11 cm. × 5 cm. and into this gap was sutured a single layer of polyvinyl sponge. This was covered by the remains of the sac and the skin. A sinus developed from the site of the drained abscess and this was explored 4 weeks after operation. A thick-walled cavity was found and this was excised. Following this the sinus almost completely closed.

Six months after operation the hernial repair is sound, but there is a slight discharge of sterile mucoid material from the sinus. This needs but a small Elastoplast dab dressing and the patient is not anxious to have further operative treatment.

Case 11.—Female, aged 72 years. This old lady had been troubled by a large rectal prolapse for several years, and had had two operations for attempted cure. On examination there was a complete rectal prolapse of about 5 in., reducible and associated with marked deficiency of the perineum. The cervix and uterus also prolapsed into the perineum. Professor Wells decided to perform an abdominal repair and at operation the whole rectum was found to have a peritoneal coat with a broad meso-rectum, so that it lay completely free in the pelvis well away from the hollow of the sacrum. There was complete atrophy of the levatores ani and all the muscles forming the pelvic floor. The pouch of Douglas was broad, deep, and hemispherical. It would have accommodated a fœtal head.

The pelvic peritoneum was incised lateral to the rectum, which was mobilized. The ureters were displayed and retracted. The lateral and posterior walls

of the pelvis were exposed, but no remains of the levator ani muscle could be identified. A series of thread sutures were then inserted on both posterolateral walls and into the periosteum of the anterior surface of the sacrum. A sheet of polyvinyl alcohol sponge was then placed around the rectum and sewn into position using the thread sutures already inserted into the lateral and posterior aspects of the pelvis.

This procedure created a new pelvic floor and fixed the rectum into the hollow of the sacrum. The recto-uterine ligaments were caught up by the sutures and so the uterus was also raised and fixed.

Following this procedure the patient has had normal bowel actions and is able to strain forcibly without any evidence of rectal or vaginal prolapse. Although it is only three months since operation, it is unlikely that the prolapse will recur as increasing fibrosis in the sponge will only fix the rectum more securely.

OTHER USES OF POLYVINYL SPONGE

In their original paper Grindlay and Clagett (1949) described the experimental use of larger blocks of polyvinyl sponge which were placed in the hemithorax following pneumonectomy in dogs. This has been applied to human surgery and Gale, Curreri, Young, and Dickie (1952) have described 50 cases in which the sponge was used to fill the space left after removal of the lung for tuberculosis. When inserted in the extrapleural space overdistension of the remaining lung was prevented. In 2 patients the prosthesis had to be removed because of sepsis. When a polythene pack was used by Morriston Davies, Temple, and Stathatos (1951), 17 out of 102 had to be removed on account of sepsis and effusion. Polythene is certainly more irritant and is incapable of absorbing any of the tissue fluids, unlike polyvinyl alcohol sponge.

Grindlay and Waugh (1951) used slices of polyvinyl sponge to wrap around aneurysms of the abdominal aorta. The invaded sponge acted as an extra-fibrous coat for the artery and further distension of the vessel was prevented by the framework of the sponge. A modification of this application has been used in grafting arteries. When a vein is used to replace the artery there is always danger of aneurysmal dilatation of the graft. This can be prevented by wrapping the vein with polyvinyl alcohol sponge.

Grindlay (1953) has used tubes of sponge as a substitute for arteries—after initial seepage through the interstices, clotting takes place and later becomes organized to form fibrous tissue. Intima rapidly grows down the lumen of the tube.

Finally there was a report in the gossip column of a Hollywood paper that a ' plastic ' surgeon had been using this sponge as a subcutaneous prosthesis in mammaplasty—to increase, not to decrease, the bulk of that organ ! No comment is offered.

CONCLUSIONS

Polyvinyl sponge is a suitable foreign-body prosthesis for use in strengthening the repair of larger defects in the abdominal wall. It is very easy to handle and to fix into position. It provides a network through which fibrous tissue can grow and bridge the defect. As it is elastic, it does not break or tear at the suture line during any stormy post-operative bout of coughing, yet it is rigid enough to prevent overstretching of the scar tissue that forms within its interstices and which is firmly adherent with contiguous tissues.

There are only very few occasions when there is any need for a foreign-body prosthesis in the repair of large herniæ. Normal tissues should be used wherever possible, but in the event of there being too large a defect or of the available tissues being of poor quality, polyvinyl sponge is a valuable substance to have available for use.

This is a preliminary report made relatively early after operation. At the moment there is nothing to suggest that the good results obtained will not be maintained, and it has been thought justifiable to publish these experiences with this new plastic.

I am most grateful to Mr. Dudfield Rose for his having asked me to operate on his two patients (*Cases* 1 and 2) at the Royal Victoria Infirmary, Newcastle upon Tyne : and to Professor Wells for permission to report his ingenious operation in *Case* 11.

The polyvinyl alcohol sponge used in most of these repairs was made to my specifications by the Ramer Chemical Co., Ltd., and is available to surgeons through the Medical Supply Association, Ltd., London, N.W.10, under the trade name of " Polyvinyl Sponge Formula B.A.T.".

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THE STOVE-IN CHEST WITH PARADOXICAL RESPIRATION

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THE stove-in chest is an uncommon injury and the complication of paradoxical respiration is rare.

Among just over 344,000 injured people treated at the Birmingham Accident Hospital during the nine years, 1944–1952, there were only 8 with paradoxical respiration requiring surgical treatment; of these, the last patient alone survived.

We wish to describe this and one other case in the light of experience accumulated from the previous ones, and to review some of the literature on the subject.

Heroy and Eggleston (1951) quote 63 cases of closed chest injury occurring in one year, 1949; of the 9 patients who showed paradoxical respiration only 4 required surgical intervention.

Elkin and Cooper (1943) reviewed 1123 chest injuries and agree that the prognosis of stove-in chest is poor.

PATHOLOGY OF PARADOXICAL RESPIRATION

Paradoxical respiration may be defined as movement of part of the chest wall in a reverse direction from normal. The essential feature is a floating segment of the chest wall which interferes with the normal thoracic mechanics. Depending on the size and mobility of the floating segment, more or less air passes from one lung to the other instead of in and out of the lung tissue as a whole. This results in :—

1. Diminished aeration of the lung.
2. Increased respiratory activity, which increases pain.
3. Inability to cough properly.
4. Marked anxiety due to the sense of suffocation (Heroy and Eggleston, 1951).
5. Interference with the normal filling of the heart.

The cardiorespiratory embarrassment which follows is directly proportional to the violence of paradoxical movement (Williams, 1948). The condition resembles a large sucking wound of the chest and mediastinal flutter may occur. Normally the intrathoracic pressure is subatmospheric, fluctuating from − 2·5 mm. Hg to − 6 mm. Hg during the respiratory cycle. The inflow to the heart via the thin-walled great veins of the chest and the auricles is assisted by the pumping action of those fluctuations in intrathoracic pressure (Hagen, 1945). Paradoxical respiration reduces the venous return to the heart by abolishing this subatmospheric pressure.

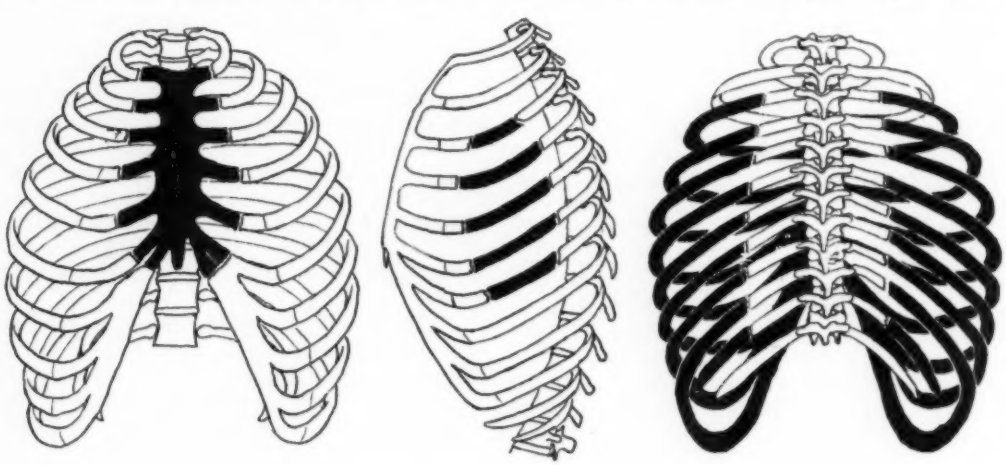


FIG. 774.—Types of injury. The floating segments are in solid black. A, Anterior; B, Lateral; C, Posterior.

6. Paralytic ileus and reflex spasm of the abdominal muscles have been observed (Key and Conwell, 1942).

VARIETIES OF PARADOXICAL RESPIRATION

1. *Anterior*, with fractures of the anterior ends of ribs or costal cartilages on each side. Injuries of the cartilages are not demonstrable by radiography (*Fig.* 774 A).
2. *Lateral*, with double fractures of the ribs on the same side (*Fig.* 774 B).
3. *Posterior*, with bilateral fractures in the region of the angles of the ribs. This is the most uncommon variety. The greater part of the chest wall has lost its posterior fixation and is thus pulled bodily downwards and backwards by the contracting diaphragm, with a consequent change in shape rather than volume of the thoracic cavity (*Fig.* 774 C).

MECHANISM OF INJURY

As a rule the injury is due to a compression force applied to the body over a wide area, the brunt of

which falls on the chest, but abdominal, pelvic, and limb injuries are commonly associated.

The *anterior type* has become known, in America, as the steering wheel injury of the chest, because the impact of the steering wheel in car accidents is such a common cause. In one of our cases to be described, however, this type of injury was produced by a patient being crushed by a bus.

The *lateral types* in our series were nearly all caused by street accidents in which the chest was crushed by being run over. Severe injuries may also occur to any other part of the body.

The *posterior type* is the rarest and did not occur in our series. Hagen (1945) describes such a case resulting from a road accident and successfully treated in a Drinker's respirator.

CLINICAL ASPECTS

The history may suggest the possibility of a stove-in chest. Restless anxiety such as is unusual in other types of serious injury is a striking feature and is associated with shock, cyanosis, and dyspnœa, the respiratory rate being 40–60 or more per minute. The degree of shock varies, depending on the nature of the other injuries.

Such a clinical picture demands immediate examination of the chest, though upper respiratory obstruction may be responsible. Paradoxical respiration is usually readily seen and may be evident even before the chest has been exposed, but in the milder forms of stove-in chest the movements of the floating segment may be slight at first; later on, if bronchial obstruction or hæmothorax develops, the additional embarrassment of respiration they cause will lead to a marked increase in the amplitude of paradoxical movement. Repeated examination is, therefore, essential.

MANAGEMENT

The essential need in treating these injuries is to cut short, as soon as possible, the disturbances of respiratory and cardiovascular function by stabilizing the floating segment of the chest. Reduction is not essential. Other treatment entails :—

1. Treatment of shock.
2. Removal of blood from trachea and bronchi.
3. Treatment of associated injuries.
4. Treatment, in collaboration with a thoracic surgical unit, of the sequelæ which may occur after approximately 48 hours (Williams, 1948). These include :—

a. Hæmothorax, to which pulmonary as well as parietal laceration may contribute.
b. Bronchial obstruction.
c. Lung abscess.
d. Pulmonary embolism.

3. Paralytic ileus.

The simplest way to reduce paradoxical respiration is to exert pressure on the floating segment as by placing a sandbag on it (Heroy and Eggleston, 1951; Bohrer and Lester, 1943), or by turning the patient on the injured side (Roberts and Tubbs, 1941). Strapping is also effective (Gardner, 1946; Ritter and Kaye, 1944), but is painful to apply and makes the chest difficult to examine. Others (Elkin and Cooper, 1943) advocate infiltration of the affected intercostal nerves with procaine.

Cyanosis responds dramatically to oxygen, particularly when given under intermittent pressure, though watch must be kept for an increasing pneumothorax.

Pain and anxiety are effectively relieved by procaine given intravenously—1 g. procaine dissolved in 500 ml. of saline and given at the rate of 160 drops per minute until the patient begins to feel dizzy and thereafter at half this rate. This may be continued or repeated as required and may be given at the same time as blood (Rook, 1951). This is a particularly valuable procedure as it does not mask the development of signs of any abdominal injury (Horn, 1951).

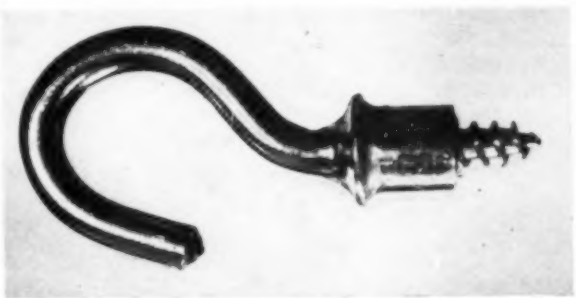


FIG. 775.—Modified cup-hook for sternal traction.

Shock is treated by intravenous infusion of blood, plasma, or a substitute, but the risk of overloading the circulation of the patients with seriously injured chests should be remembered (Ruscoe Clarke, 1953).

Once these immediate needs have been met, the case can be more carefully assessed and a definitive line of treatment planned.

Pressure on the floating segment is an excellent first-aid measure, but traction is a better form of definitive treatment because it leaves the undamaged part of the chest free to move normally and does not further reduce the volume of lung available for gaseous exchange.

Fixation of the Floating Segment.—With the lateral type of injury fixation must be applied to the ribs in the floating segment, but in the anterior type either the sternum or its costal stumps may be secured.

Fixation of Ribs and Costal Cartilages.—

1. Wires (Bohrer and Lester, 1943; Joslow, 1946), or unabsorbable suture material (Ritter and Kaye, 1944), may be passed around the ribs on an aneurysm needle. This method was used in our successfully treated case, but it is better avoided on the costal cartilages because of the risk of troublesome chondritis.

2. Ribs or cartilages may be gripped by towel clips.

Fixation of the Sternum.—

1. The anterior cortex may be gripped by towel clips or similar instruments (Heroy and Eggleston, 1951).

2. Various types of hooks may be screwed into the sternum, e.g., coat-hanger hooks (Joslow, 1946), corkscrews (Campbell, 1943), and cup hooks. Dr. J. R. Rook has designed a modified cup hook for this purpose (*Fig.* 775). Though this penetrates only the anterior cortex, two such hooks have a sufficiently firm hold to support the weight of the patient's head and shoulders.

It is important to realize that not all the fractured ribs require such fixation. Traction on one rib may suffice to control quite a large segment of the chest, and three to five traction points will usually control the whole of one side of the chest when this is unstable.

In order to maintain traction a thoracic stabilization frame has been designed by Mr. J. S. Horn.

The Thoracic Stabilization Frame (*Fig.* 776 A, B).—This consists of a base and an overhead frame. The base (**A**) is made of two aluminium sheets 18 in. square, each bearing along one side a metal tube, inside diameter ¾ in., the ends of which are turned up at right angles (**B**). These aluminium sheets can be pushed in under the mattress without disturbing the patient, and the upturned tubes project on each side as sockets for the overhead frame.

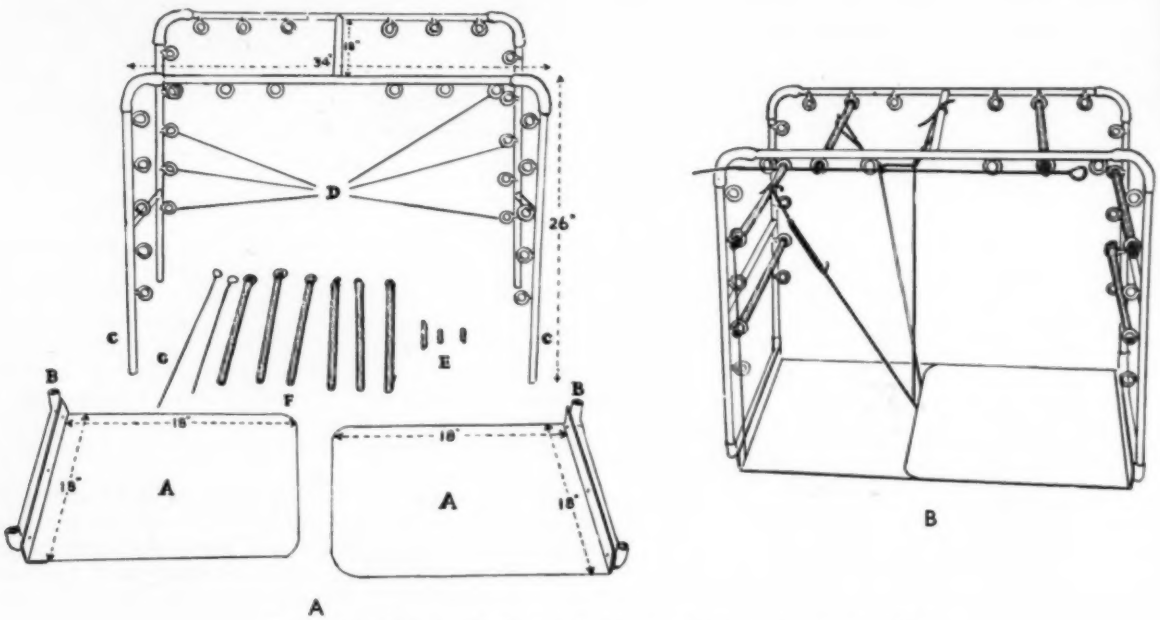


FIG. 776.—Thoracic stabilization frame. A, Components; B, Assembled.

The overhead frame (**C**) consists of two parallel bars, outside diameter ⅝ in., which form three sides of a rectangle 34 in. wide and 26 in. high, and are joined together by strong crossbars 18 in. long above and at the sides. This frame is then placed over the patient with the bars fitted into the sockets on the base plates.

Each side of the overhead frame has five or six metal loops (**D**) on it. Traction in the right direction is maintained by attaching the traction wires to light springs (**E**) and these to metal rods (**F**), of which there are six provided. The requisite number are inserted through the appropriate loops. The rods are prevented from slipping out by skewers (**G**) passed through their ends. *Fig.* 776 B shows the frame erected, and *Fig.* 777 shows the frame in use.

The primary purpose of this frame is to provide a quick and easy means of applying traction in the admission department of any casualty service. It will fit inside an oxygen tent should this be necessary and allows the patient to be moved by ambulance.

We have found that simple traction over pulleys is an improvement over the fixed frame, as the patient is free to move about in bed, the traction adjusting itself automatically while nursing, radiography, or thoracentesis is carried out.

CASE REPORTS

Two patients are described. The first had the anterior type of injury and died on the twelfth day; the second had the lateral variety and survived.

Case 1.—**Anterior Type.** L. W. aged 50.

At 11.30 p.m. on Dec. 13, 1950, he was climbing out of an inspection pit in a garage when he was struck by a reversing bus.

ON ADMISSION.—He was conscious, cyanosed, respiration rate 60/min., entire sternum mobile, with a startling amplitude of paradoxical movement. Clinically all the costal cartilages on both sides of the sternum were disrupted. Further, he had a ruptured bladder and a fractured pelvis.

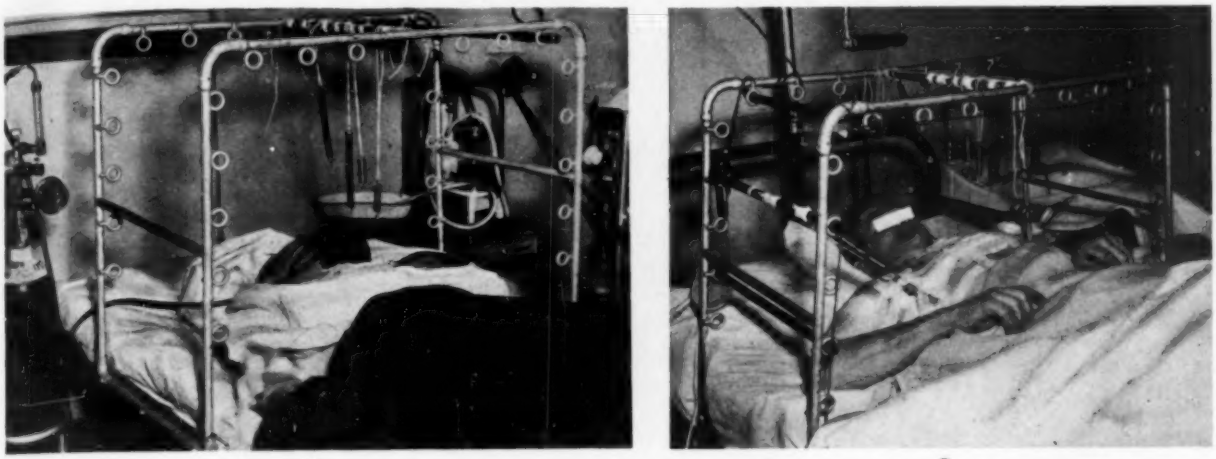
Radiography.—On the right side—fractures of clavicle, acromion, the necks of ribs 2-9. On the left side—fractures of the necks of ribs 1-6 and shafts of 7, 8, and 9 in the posterior axillary line. Pelvis—dislocation of right sacro-iliac joint with 5 cm. separation of symphysis pubis.

TREATMENT.—Oxygen under intermittent pressure and an intravenous infusion of procaine were started at once.

Under local anæsthetic the patient was intubated and gas, oxygen, and gallamine triethiodide were given to prevent the rapid and deep movements of the sternum. A silk suture was passed under the sternal stump of each second and fourth costal cartilage (see *Figs.* 777 A, B). The sutures were then fixed to an overhead bar on the thoracic stabilization frame. Paradoxical movement of the sternum was abolished and the chest had a very good air entry, though there was still slight paradoxical movement on the right side. *Fig.* 777 A shows the patient in the frame at 2.30 a.m. Tracheobronchial toilet was then performed and a moderate amount of blood and mucus obtained.

Twelve hours after injury his general condition was quite good. Hb 103 per cent, hæmatocrit 50, and his breathing was quiet. Suprapubic drainage was then

established under local anæsthesia, a 5-cm. rent in the anterior wall of the bladder being found. Intravenous procaine and blood were continued and the patient pulse, and respiration were normal. His hæmoglobin was 80 per cent and radiography did not reveal any effusion in the chest.



A B

FIG. 777.—Thoracic stabilization frame in use. *Case* 1. A, Anterior stabilization only (Dec. 14, 1950); B, Right segment also stabilized (Dec. 20).

started on a course of penicillin and streptomycin. Tracheo-bronchial toilet was performed approximately every four hours.

On the second day a segment of the right chest showed increased paradoxical movement, which was controlled by two further sutures passed around two ribs in the floating segment under local anæsthesia (*Fig.* 777 B).

On the third day his condition was satisfactory, oxygen was given intermittently, and his temperature,

On the seventh day he developed sudden pain in the calf of his left leg associated with slight increase in respiratory rate and a pulse of 128 min.

On the ninth day the patient became slightly jaundiced. Then on the twelfth day he died suddenly from a pulmonary embolus. Permission for an autopsy was not obtained.

FIG. 778.—*Case* 2. Chest on admission (Dec. 18, 1951).

FIG. 779.—*Case* 2. Leg on admission.

Case 2.—**Lateral Type.** Mrs. A. C., aged 54.

While crossing the road on Dec. 18, 1951, she was struck by a car coming from her left.

ON ADMISSION.—The two main features of her condition were a severe compound fracture of the left leg and marked respiratory distress. She was in a state of restless anxiety, with cyanosis and rapid respiration. Exposure of the chest showed that most of its left side was moving paradoxically. Oxygen given under intermittent pressure relieved her cyanosis and anxiety.

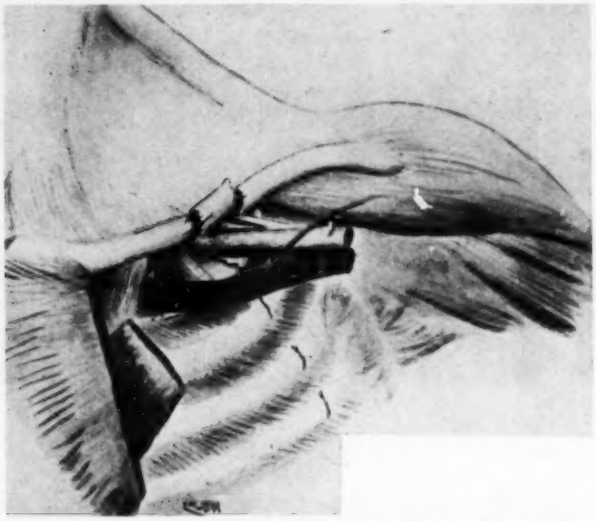


FIG. 780.—*Case* 2. Diagram showing crushed subclavian artery between clavicle and first rib. The bruised segment had a sharp lateral border corresponding with the lateral edge of the first rib but faded gradually in a medial direction.

She also had a large hæmatoma over the left clavicular region with a fracture of the clavicle. The left arm and hand were cool and cyanosed and no pulse could be felt in the limb. The nerve-supply to the hand was intact. Cautious movements of the left arm and shoulder girdle did not affect the circulation of the limb.

Radiographs showed fractures of the left clavicle, scapula, and the upper ten ribs on the left side (*Fig.* 778). In spite of the gross displacement of the fracture the circulation and sensation in the left lower limb were normal (*Fig.* 779).

After cyanosis had been relieved with oxygen and an intravenous infusion of blood and procaine started she was turned on her left side and was then able to continue inhalation of oxygen without assistance. The leg was dressed and splinted as it lay by the application of a temporary plaster.

Her injuries were then assessed. There were three main considerations in planning definitive treatment:—

1. The unstable chest wall.
2. The vascular injury to the left arm.
3. The severe compound fracture of the left leg.

In these circumstances it was considered justifiable to give a general anæsthetic and to deal first with the chest and stabilize it by open operation. Then if the patient's condition permitted, to explore the vascular injury, and finally, to deal as simply as possible with the compound fracture. If the patient's condition, however, was too poor then the exploration of the vascular injury would have to be left.

The plan was designed to diminish, as far as possible, the need for any further major surgery during the next few weeks.

The anæsthetic was given by Dr. D. J. Carter; 0·2 g. thiopentone and 80 mg. of gallamine triethiodide were given, a cuffed tube passed, and anæsthesia maintained with cyclopropane and oxygen.

AT OPERATION.—A 27-cm. slightly curved incision was made extending from the mid-third of the left clavicle to approximately the 8th rib, around the breast. The breast was reflected medially. The floating segment was now obvious, and it was easy to select the key ribs on which traction had to be exerted. It was not, however, quite so easy to pass the wires around the ribs; they had first to be grasped with Lane's tissue forceps to steady them. Wires were passed with an aneurysm needle around the 2nd, 3rd, 5th, and 7th ribs, but, owing to the comminution of the ribs in the floating segment, a further wire had to be passed around the 7th rib before paradoxical movement was completely controlled when traction was exerted on these wires by an assistant. The

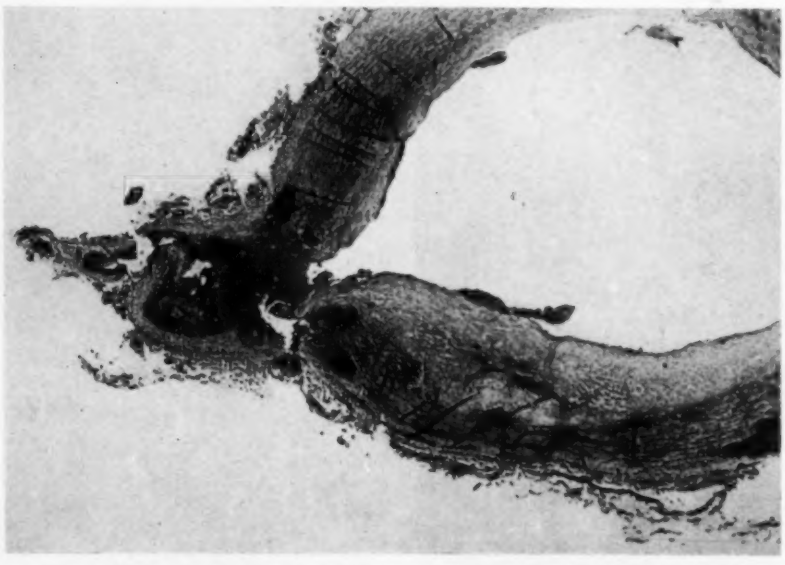
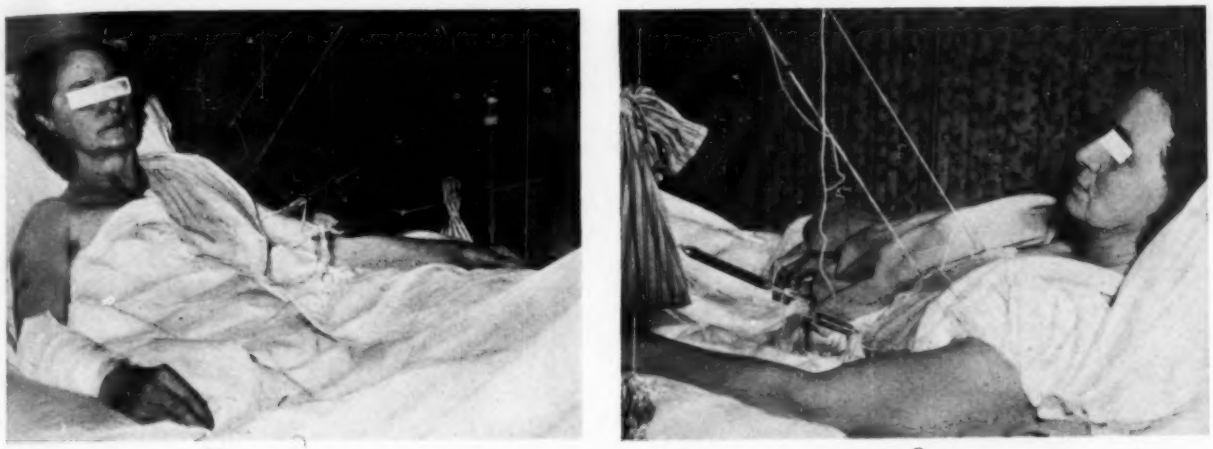


FIG. 781.—*Case* 2. Photomicrograph of excised segment of artery. The arterial wall has been partly ruptured in one place and is infiltrated with blood. Elsewhere are hæmorrhagic foci. There are a few intimal thrombi; the clot which completely filled the lumen at the time of excision has been dislodged during the preparation of the specimen.

patient's unaided respiration was now adequate and her general condition was surprisingly good.

The incision was extended along the clavicle and a loose middle fragment about 4 cm. long was found to be displaced. This fragment was removed, but no pulsation could be felt in the arm, so the subclavian artery was dissected out and showed marked bruising, with a sharp lateral margin overlying a fracture of the first rib (*Fig.* 780). The vein and the cords of the plexus were uninjured and were left undisturbed. No change was noted in the colour of the hand when the first part of the axillary artery was compressed, so the damaged segment was removed between ligatures. Its lumen was completely obstructed and *Fig.* 781 shows that the intima had been damaged. This provided striking evidence that costo-clavicular compression of the artery can occur, though perhaps only in exceptional circumstances such as these. While the chest wound was being closed and drained the wires were brought through the skin or suture line so as to maintain traction in the right direction on each. One wire had to be brought out through the middle of the breast substance. During this stage of the operation the compound fracture of the leg was thoroughly cleansed, the 12-cm. wound was sutured and the leg placed in good alinement and encased in a well-padded plaster cast from the toes to the upper third of the thigh.

At the end of the operation the traction wires were attached to the thoracic stabilization frame. There was



A B

FIG. 782. - *Case* 2. Stabilization assembly on Dec. 24, 1952. Though shown here, the springs are not necessary with weight and pulley traction.

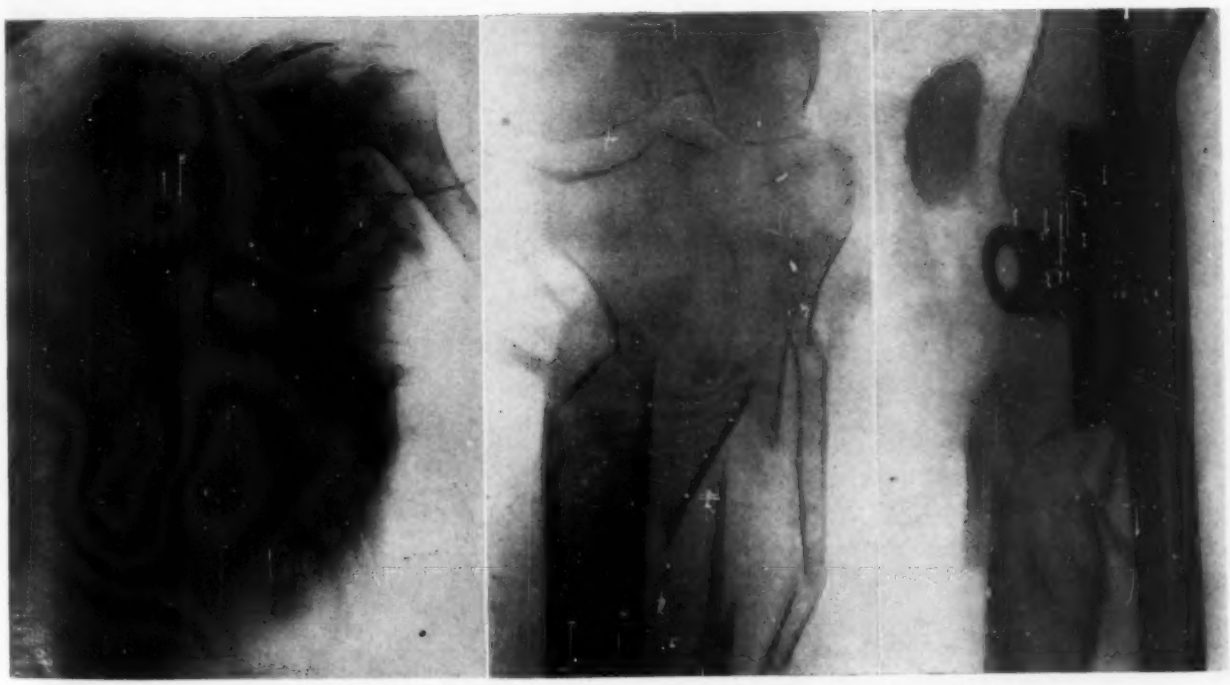


FIG. 783.—*Case* 2. Chest on the day after injury. The second wire has slipped off its segment of rib. The upper part of the chest has fallen in considerably.

FIG. 784.—*Case* 2. Leg the day after injury.

no paradoxical respiration, the patient's general condition was good, and she was a good colour without oxygen. She had seven pints of blood from the time of admission to the end of the operation. The left arm remained dusky, cool, and pulseless.

After operation intravenous saline containing 0·2 per cent procaine was continued at the rate of 180 ml. an hour (60 drops a minute). Fifty mg. of Priscol was also given by intravenous injection and continued daily. Tracheo-bronchial toilet was performed.

slipped off its rib. The radiograph of the leg showed satisfactory alinement but poor apposition (*Fig.* 784).

On the third day the drain was removed from the thoracic wound. Hæmoglobin 97 per cent; blood-urea 25 mg. per cent.

On the fourth day her condition had deteriorated a little—temperature 99·8°, respiration 32 (*see Fig.* 785). Her procaine drip was discontinued as, apart from a heavy feeling in the left arm, she was free from pain. Movement and sensation in the fingers of the left hand

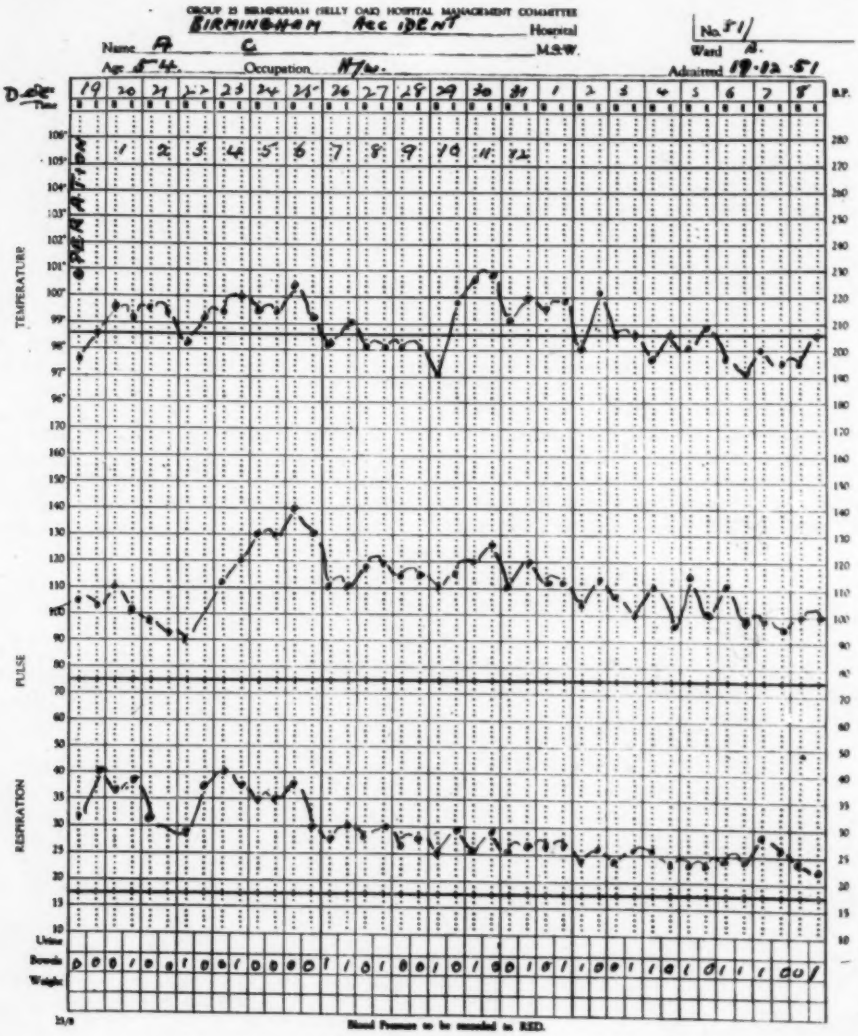


FIG. 785.—*Case* 2. Clinical chart for the first three weeks after injury.

PROGRESS.—On the second day (Dec. 19) her general condition remained quite good, though she was vomiting some altered blood and this tended to make her a little dyspnœic. She was, therefore, given some oxygen during the course of the day. At night she was propped up in bed and the thoracic stabilization frame removed, traction being continued by 1-lb. weights over pulleys fixed to a Balkan beam diagonally across the bed and to a drip stand by the side of the bed (*Fig.* 782 A, B). She felt better for this and could be moved more freely for nursing purposes and could be radiographed. The left hand become more cyanosed with the change of position.

Her chest radiograph (*Fig.* 783) showed considerable deformity in spite of traction. The second wire had

were quite good and her grip fairly strong. Priscol was continued by mouth 25 mg. 6-hourly.

On the fifth day her dressing was changed and for the most part her wound was healthy. She was, however, complaining of pain in relation to the wire that had slipped off its rib; it was therefore removed. The weights attached to the upper three remaining wires were removed for three hours; during this time the patient's respiratory function appeared to be satisfactory, but she complained bitterly and was showing the restless anxiety which is so marked a feature in these cases before the chest is stabilized. The weights were, therefore, replaced and traction continued.

The sutures were removed from the chest wound on the ninth day.

On the eleventh day she felt less well. Temperature 100°, pulse 120, respiration 30 (*see Fig.* 785), and a radiograph of the chest showed a large left-sided effusion

FIG. 786.—*Case* 2. State of chest 9 days after injury. The upper part of the chest has collapsed further. Thoracentesis yielded 900 ml. blood-stained liquid after this.

FIG. 788.—*Case* 2. Position of fractures of left leg on Jan. 11. Further displacement has occurred, but manipulation did not improve this position.

(*Fig.* 786). Thoracentesis was performed and approximately 900 ml. of blood-stained effusion was removed. This was sterile on culture.

On the twelfth day she felt better, but complained of pain around the lowest of the wires which had been brought through the suture line. There was some inflammatory reaction around it, with local induration, and the wire was, therefore, removed.

On the fourteenth day her hæmoglobin was 64 per cent but she felt quite well. Nevertheless she was given two pints of blood. The traction weights were removed

FIG. 787.—*Case* 2. State of chest Jan. 7, 1952 (20 days after injury). 220 ml. blood-stained liquid withdrawn after this.

FIG. 789.—*Case* 2. State of chest on Jan. 12 (25 days). Early aeration of upper part of lung in spite of further collapse of overlying chest wall. Residual basal effusion.

overnight and the patient slept well. The three remaining wires were, therefore, removed on the fifteenth day; 1 lb. traction had been maintained on each of three wires for fourteen days and on the fourth for twelve days.

On the twentieth day radiography of the chest showed that an effusion was still present and showed a rather arm was of normal colour and had good movements and quite good power.

On the thirty-first day she was allowed up and was walking with crutches on the thirty-third day. Her left chest showed considerable deformity, but her left shoulder movements were quite good (*Fig.* 790 A-E).

FIG. 790.—A–E, *Case* 2. Appearance of chest and range of movement of shoulders on Jan. 23 (5 weeks after injury). She had managed a few steps with crutches by this time.

bizarre appearance of the chest which is virtually that of a complete thoracoplasty (*Fig.* 787). Thoracentesis was performed and 220 ml. of blood-stained effusion obtained. The right leg was radiographed and this showed some loss of position (*Fig.* 788). In view of her good general condition it was decided to try and improve the position by manipulation.

On the twenty-fourth day the plaster was removed, the wound was soundly healed, but no amount of manipulation could improve the position. Her leg was, therefore, replastered. Further radiography of the chest showed considerable clearing of the left lung field, though there was still a slight effusion at the base (*Fig.* 789).

On the twenty-seventh day the penicillin was stopped as she was now apyrexial and feeling very well. The left

As the position of the fractured tibia was so poor, open reduction was performed on Jan. 25, 1952, five weeks after injury. The spike of the distal fragment was inserted into the medulla of the proximal fragment and fixed with a circlage wire. A plaster cast was applied from the toes to above the knee. Radiography showed a satisfactory position (*Fig.* 791). She stood the operation well and the anæsthesia gave rise to no difficulty or post-operative complications.

Further radiographs showed that the position of the tibial fracture remained unchanged and that the chest was now clear on the left side, though there was considerable deformity (*Fig.* 792).

She was finally discharged on the seventy-second day and followed up as an out-patient.

A year after injury the chest was clear radiologically and caused her no trouble (*Fig.* 793). Her right tibia was soundly united by bone (*Fig.* 794) and she was putting her full weight on it, though experiencing some pain in the knee-joint. She had 90° of knee flexion, though this was accompanied by some grating in the joint. There was marked deformity of the chest and her shoulder movements were about half normal. The left arm was

FIG. 791.—*Case* 2. Position of fractures after open reduction on Jan. 25.

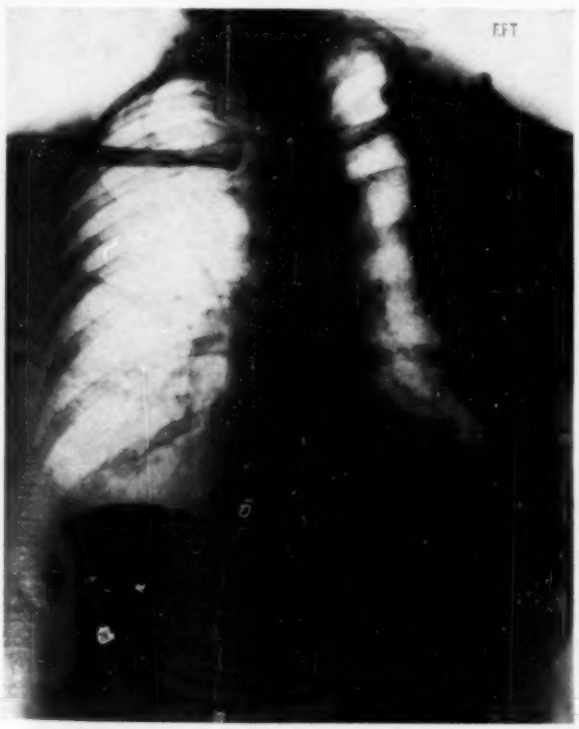


FIG. 792.—*Case* 2. Chest on Feb. 6. Left lung clearing well.

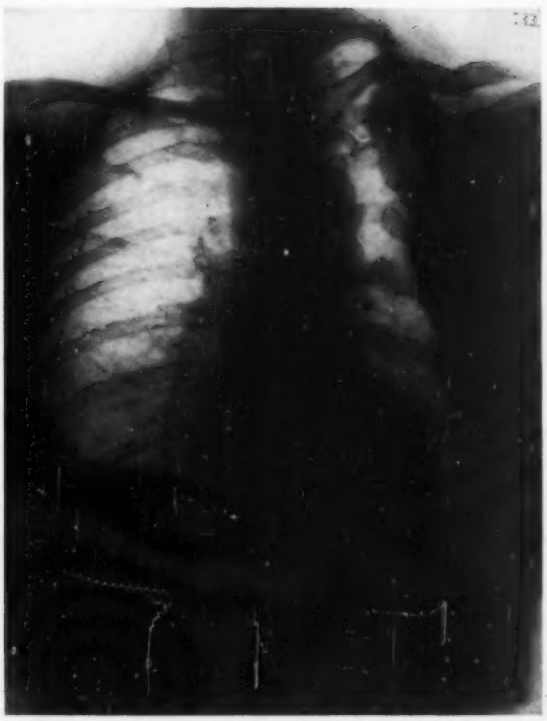


FIG. 793.—*Case* 2. State of chest nearly a year after injury. Final clearance of base of left lung. Bony union of many ribs and of the clavicle in spite of the removal of about 1½ in. at the operation.

normal in colour and sensation and distal to the shoulder had full movements and power. No pulsation could be felt in the arm.

SUMMARY AND CONCLUSIONS

Stove-in chest with paradoxical respiration is a rare form of injury, but serious because it disturbs respiratory and cardiovascular functions. Crushing is the most frequent cause, and as the violence may not be confined to the chest other injuries are common and must be sought, particularly in the abdomen.

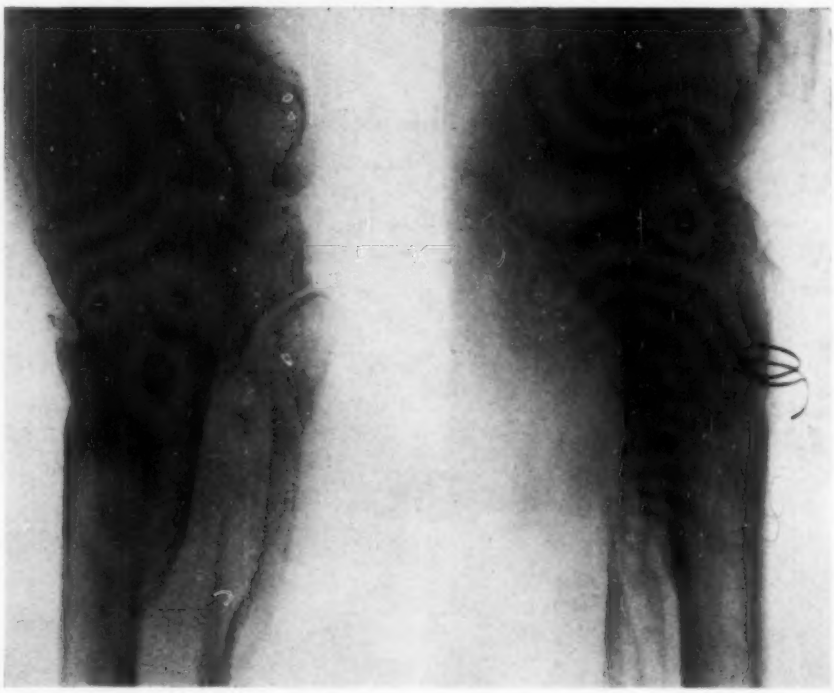


FIG. 794.—Bony union of left leg nearly a year after injury. Flexion of knee to 90° in spite of tilting of part of the lateral condyle of the tibia.

The basic cause of the disturbances that follow this type of injury is the instability of part of the chest wall and the basic consideration in management is its prompt stabilization. As a first-aid measure pressure on the unstable segment is recommended, but traction is advised as the definitive method of treatment. Simple weight-and-pulley traction using towel clips or pericostal wires or sutures has the double advantage of requiring no special equipment, and of leaving the patient free to be moved in bed for nursing and examination. Of the various forms of screw hook, Rook's pattern is probably the best and is recommended for fixing a floating sternum. The stabilization frame is a valuable piece of equipment for a Casualty Department if an oxygen tent is used or if the patient has to be transported.

The fact that *Case* 2 survived and returned to a fairly normal life in spite of the marked deformity of her chest makes it clear that stabilization and not reduction of the unstable segment is the essential objective, though it would be tempting in a similar case to try, by using heavier weights, to prevent the progressive collapse that her chest showed. Our patient's remarkable sensitivity to alterations of the traction suggests that more weight than suffices to prevent paradoxical movement may be intolerable.

Other considerations in management fall into early and later groups. *Early*: Pain and anxiety respond well to procaine given intravenously. Shock and any associated injuries require appropriate treatment. Bronchial obstruction by blood and mucus can occur at any time from the earliest stages onward, and repeated suction may be required. Local analgesia is adequate for the insertion of traction appliances, but general anæsthesia, if skilfully given, is not apparently harmful. *Later*: Hæmothorax and pulmonary collapse may occur and so embarrass respiration that paradoxical movement appears in new areas, as was the case with Mr. L. W. Other pulmonary complications include abscess and infarction; paralytic ileus has been reported.

We should like to thank Mr. William Gissane, Clinical Director of the Birmingham Accident Hospital, for permission to publish this paper and for his help and advice; Mr. F. G. Badger for allowing us to report his patient, *Case* 1; Dr. J. R. Rook and Mr. J. S. Horn, for much practical help and the use of the thoracic stabilization frame. To Mr. Gill and Mr. Richardson, of the Photographic Department, we wish to extend our thanks. To Mr. R. C. Baillie we are indebted for *Fig.* 784.

Further we should like to pay tribute to the indomitable cheerfulness and inspiring courage of the patient in *Case* 2.

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A PEPTIC ULCER IN A COLONIC TRANSPLANT

BY G. B. D. SCOTT

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THE formation of a peptic ulcer in the upper jejunum is a well-known occurrence in cases of gastro-jejunostomy. The finding of peptic ulcers in the colon from whatever cause is by no means as common, and the following example in a colonic transplant is of interest.

CASE REPORT

CLINICAL HISTORY.—B. D., a male aged 50, was admitted to St. Mary's Hospital, Paddington on May 28, 1951.

For fifteen years he had experienced a progressive gnawing pain in the left hypochondrium, situated under the costal margin. This pain came on 1½-2 hours after food, was relieved by taking alkalis and by vomiting and was brought on by alcohol. There had been no hæmatemesis or melæna.

ON EXAMINATION.—A small area of tenderness was found in the midline, midway between the xiphisternum and the umbilicus. A barium meal revealed an ulcer on the lesser curvature of the stomach at the incisura angularis.

AT OPERATION.—A high partial gastrectomy and colonic replacement was performed on June 5. A length of transverse colon was substituted for the portion of stomach excised, the distal end being anastomosed to the cardiac end of the stomach and the proximal end to the duodenum. The continuity of the transverse colon was restored by end-to-end anastomosis.

The excised specimen measured 21 cm. along the greater curvature. An active benign chronic gastric ulcer, 1·0 cm. in diameter, was situated on the lesser curvature 4·5 cm. from the pylorus. There was some fibrosis in the short duodenal stump suggestive of a healed duodenal ulcer.

FIG. 795.—Colonic transplant. Mucosal surface showing ulcer crater near gastrocolic anastomosis. (× ⅔.)

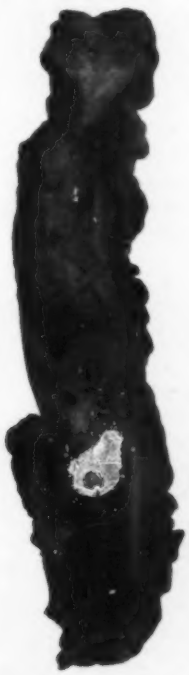

FIG. 796.—Colonic transplant. Ulcer penetrating muscularis.

PROGRESS.—The immediate post-operative progress was satisfactory, but on Sept. 9, 1952 he complained of a recurrence of epigastric pain, although gastroscopy and a barium meal failed to reveal any ulcer. The pain persisted, and on March 13, 1953, the transplanted colon was excised and a Billroth I gastroduodenostomy was

performed. From then onwards he was free from pain and was still symptom-free when last seen on Jan. 14, 1954.

EXAMINATION OF THE SPECIMEN.—The specimen consisted of 10 cm. of colon with 1·0 cm. of stomach firmly anastomosed to its proximal end. An ulcer crater 1·2 × 0·5 cm. and 0·7 cm. deep was present in the colon close to the gastrocolic anastomosis (*Fig.* 795). The ulcer had penetrated the muscularis and there was much fibrosis in and around its base (*Fig.* 796).

Histological examination showed that the colonic mucosa was heaped up around the edges of the crater (*Figs.* 797, 798). In the floor of the ulcer a fibrinous exudate, containing lymphocytes, covered a layer of

FIG. 797.—Ulcer. (H. and E.) (× $\frac{3}{4}$.)

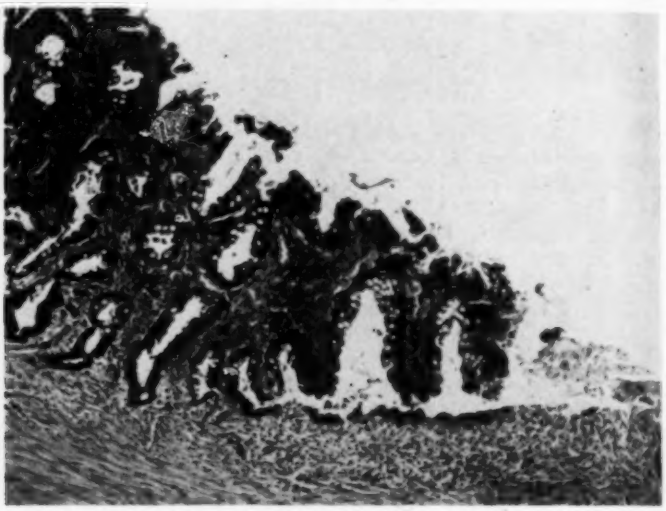

FIG. 798.—Heaped-up colonic mucosa at edge of ulcer. (H. and E.) (× 75.)

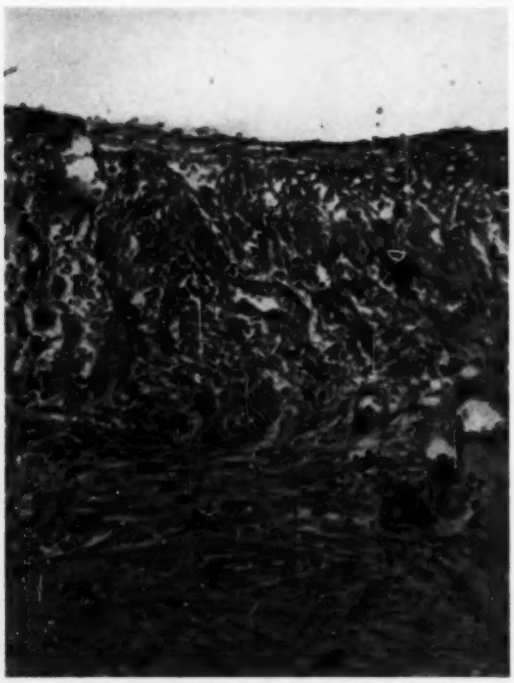

FIG. 799.—Fibrinous exudate covering granulation tissue. (H. and E.) (× 150.)

FIG. 800.—Fibrous tissue lying deep to granulation tissue. (H. and E.) (× 150.)

granulation tissue (*Fig.* 799), while the deeper part of the ulcer was composed of fibrous tissue, which had completely replaced the muscularis (*Fig.* 800). The arteries showed marked endarteritis obliterans (*Fig.* 801), while signs of healing were seen at the edge of the ulcer in the form of epithelium growing over the granulation tissue (*Fig.* 802). The changes were those of a chronic benign peptic ulcer, typical in every respect except that it affected the colon.

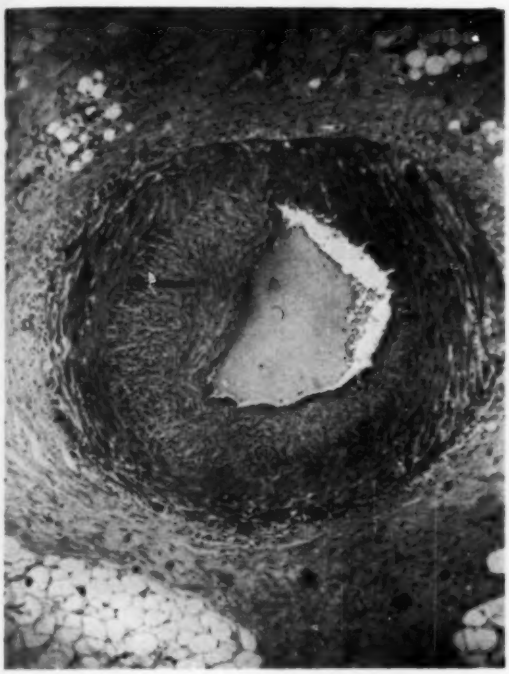

FIG. 801.—Artery showing endarteritis obliterans. (H. and E.) (× 60.)

FIG. 802.—Epithelium growing over granulation tissue. (H. and E.) (× 250.)

DISCUSSION

Jejunal and colonic replacements are designed to overcome post-gastrectomy 'dumping' symptoms. Henley (1953) and Moroney (1953) report that both these procedures reduce the incidence and severity of this condition, although the former author records the formation of an ulcer in the jejunal transplant in 4·1 per cent of cases, while the latter records an ulcer in the transplant in 2 out of 150 cases of colonic replacement.

The formation of peptic ulcers in jejunal and colonic transplants is not surprising, as it is well known that the mucosa of these two organs is less resistant to hydrochloric acid than that of the stomach.

I am indebted to Professor J. C. Goligher for permission to publish this case; to Professor W. D. Newcomb for helpful criticism; and to Mr. A. Beasley and the Photographic Department of St. Mary's Hospital Medical School for technical assistance.

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GASTROCYSTOMA OF THE SPINAL CORD

BY GEOFFREY KNIGHT, TREVOR GRIFFITHS, AND IOLO WILLIAMS, LONDON

CONGENITAL intradural tumours of the spinal cord other than dermoids and epidermoids are rare. In 1931 Hosoi collected from the literature 10 cases of teratoma occurring in patients of all ages. In 1951 Furtado and Marques discussed 21 recorded examples of intraspinal teratoma, of which 10 occurred in patients over the age of 10 years, the remainder arising in younger subjects. The majority of these recorded examples have contained tissue elements derived from only 2 of the primary germinal layers, ectodermal and mesodermal. In only 1 case, recorded in 1934 by Puussepp, has intestinal epithelium been recognized within the tumour. Hence it would appear that an example of intramedullary gastrocystoma arising in a child of 2 is unique and worthy of report.

It is curious that intraspinal teratomas should be so few in number, for the location of teratomas is almost always median in relation to the axis of the body, a fact to be explained by their origin from the embryonic stem and its invaginated derivatives, and yet, in relation to the spinal axis they are usually

seen only as extraspinal and extradural tumours in the sacral and sacrococcygeal regions.

In reviewing the recorded examples of the intraspinal group the following facts emerge: Intraspinal teratomata may occur in association with other congenital abnormalities such as spina bifida and polydactylism or with abnormalities of the spinal cord such as syringomyelia. They are distributed at almost all levels in relation to the spinal axis, the terminal portion of the column being the site of preference. They are only rarely intramedullary in relation to the cord, but may be either intradural and adherent to the cord or extradural with an intradural extension. Teratomatous tumours in general are cystic, the cyst being variable in size and containing either whitish fluid, turbid from the presence of degenerating cells and mucin or inspissated caseous material. The histological structure is characterized firstly by the disordered grouping of the various tissue elements, which are distributed without the slightest attempt at organization into layers. The majority of the tumours contain tissues derived from two germinal layers only, being bidermoid or teratoid rather than true teratomas; as Hosoi (1931) and Bucy and Buchanan (1935) point out, the endoderm is the germinal layer which is not represented among the tissues present, all the structures commonly met with being of ectodermal or mesodermal origin. Skin fragments, stratified epithelium, sebaceous and sudoriferous glands, portions of nervous tissue, bundles of neuroglial tissue, choroid epithelium, and ganglion cells have been observed together with muscle-fibres, cartilaginous and osseous tissue, and structures which are hard to identify, including cysts lined with columnæ ciliated and columnæ and cuboidal cells, and frankly embryonal tissues. Many varieties of mature and embryonal tissue are found in varying stages of differentiation arranged in a disordered array.

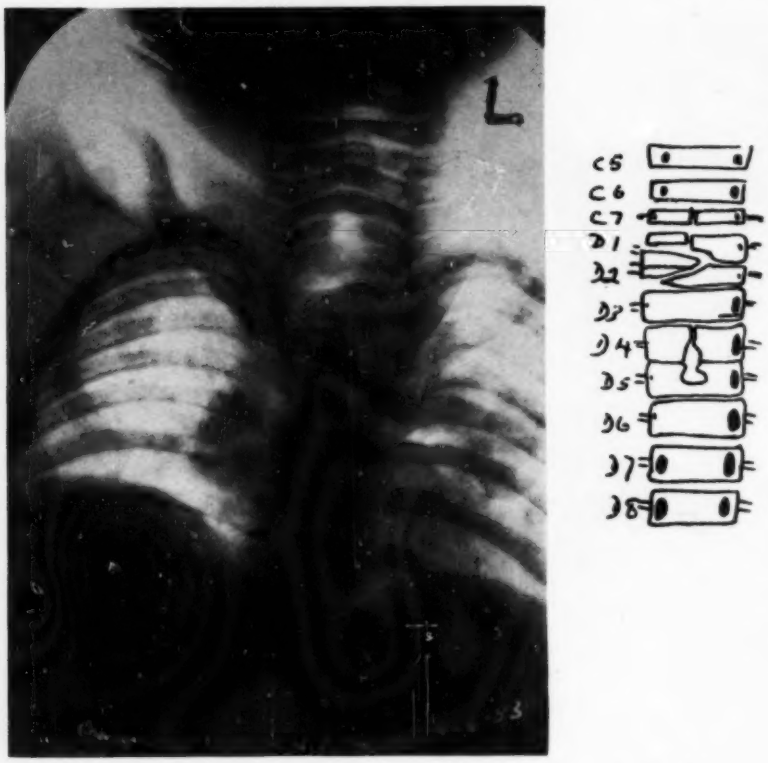

FIG. 803.—Anteroposterior radiograph and line drawing of cervical and dorsal spine.

From this review of previously recorded teratomas it would appear that the present case of gastrocystoma is unique and is, we believe, the only recorded example of such a lesion. It differs from the recorded examples of teratoid tumour in many respects; in the remarkable organization of the cyst into orderly inner and outer layers, in the high degree of maturity of the glandular tissue which gives the appearance of full differentiation, and capacity of function. It would appear to be not a teratoma but a congenital ectopic cyst which has been extruded into the spinal canal through an area of anterior spina bifida in the vertebral bodies, and may, or may not, be related to a corresponding tumour in the mediastinum.

CASE REPORT

G. H., aged 1 year 3 months, was admitted to the South-East Metropolitan Regional Neurosurgical Centre at the Brook General Hospital on May 21, 1953. At the age of 10 months the child had been investigated at a Children's Hospital on account of fretfulness, cervical rigidity, and tension in the anterior fontanelle. Tuberculous meningitis was suspected, but lumbar puncture had yielded a clear colourless fluid containing 1 polymorph and 10 lymphocytes per c.mm. Protein 400 mg. per cent, sugar 40 mg. per cent, and chlorides 680 mg. per cent. No organisms or tubercle bacilli had been isolated and a tentative diagnosis of meningo-encephalitis having been made, the child was discharged on May 16. However, the child remained irritable and fretful and failed to sit up, and on account of these persistent symptoms was admitted to the Regional Neurosurgical Centre for investigation.

ON EXAMINATION.—The child screamed when disturbed, but exhibited no meningeal signs. It could not be brought into the sitting position without support. The arm reflexes were normal, but sustained ankle clonus and bilateral extensor plantar responses were demonstrated. Lumbar puncture showed a faintly xanthochromatic fluid containing 1 cell per c.mm. and protein 2 mg. per cent. Examination of radiographs taken at the time of admission to the Children's Hospital showed extensive abnormalities in the lower cervical and upper dorsal spine. Further films, including lateral tomographs, were requested, and Dr. Trevor Griffiths reported as follows:

X-ray Report.—The greater part of the dorsal spine showed gross abnormalities; these are of such a degree that identification of the individual vertebræ is somewhat uncertain. The abnormalities include hemivertebræ and partially fused vertebræ. The bodies of the first to the sixth dorsal vertebræ all exhibit varying degrees of fusion to each other. In the fourth and fifth dorsal vertebræ this fusion is complete. In addition, the 7th cervical and 1st, 2nd, 4th, and 5th dorsal vertebræ show incomplete fusion of the lateral halves of the vertebral bodies. In the case of D.1 and D.2 the

development of the lateral halves of the bodies is not of equal degree on each side. These abnormal vertebral bodies are broader than normally developed vertebræ, so that the distance between their pedicles is necessarily greater than normal. Several of the pedicles are, however, thinned, some of them to such an extent that they cannot be identified. There is an anterior spina bifida involving the 5th dorsal vertebra. The lateral view shows that the posterior surfaces of the vertebral bodies in the affected region are scooped out. This finding was confirmed by tomography. The vertebral arches appeared to be intact at all levels. (*Figs.* 803, 804.) The radiographs demonstrate :—

1. Developmental abnormalities of the vertebræ between C.7 and D.7.

2. Gross enlargement of the neural canal in much of this region.

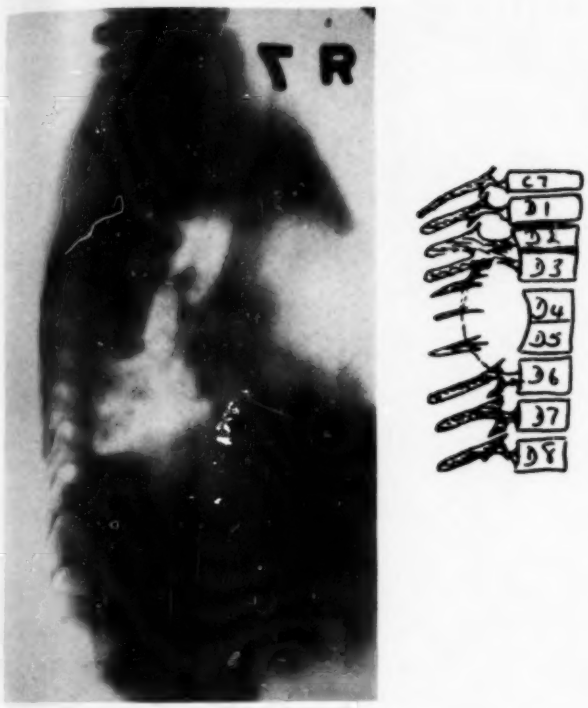

FIG. 804.—Lateral tomograph and line drawing of upper dorsal spine.

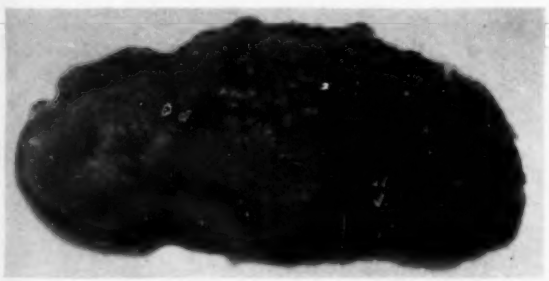

FIG. 805.—Photograph of oval tumour which was strawberry coloured, 3½ cm. in longest diameter and 1·5 cm. in cross-section at its widest part.

AT OPERATION (June 23, 1953).—A cervicodorsal laminectomy was performed under general anæsthesia. The dura was found to be widely expanded and stony hard from the level of the 7th cervical to the 7th dorsal vertebra. An aspirating needle was introduced into the substance of the cord and a cyst containing 3 c.c. of milky fluid was aspirated, producing a sufficient reduction of tension to enable the dura to be opened with safety. On opening the dura the cord was seen to be widely expanded, with cystic cavities lying superficially within the dorsal portion of its substance.

Careful examination of the lateral aspects of the cord failed to reveal any plane of demarcation between the cord and the tumour—indeed, the space between the line of emergence of the anterior and posterior roots was increased, as it is with intramedullary tumours. Accordingly, a vertical incision was made between the posterior columns strictly in the midline of the cord at the site of the cystic areas. At a depth of a few millimetres a strawberry-coloured tumour was revealed occupying the midline of the expanded cord (*Fig.* 805). The two halves of the cord which passed down on either side of the mass were lightly adherent to its surface at one or two zones and were readily separated from these points of light attachment by soft dissection. Around the greater part of the circumference of the tumour the cord tissue was separated from the growth by cyst formation which had occurred between the tumour surface and the cord substance, and was easily separated, revealing a tumour arising in connexion with the bodies of the vertebra and projecting backwards to become enwrapt within the cord. The vessels entering the anterior aspect of the tumour from the vertebral bodies were secured with silver clips and the tumour was rotated upwards from its bed and delivered.

The post-operative recovery was uneventful. After a period of pyrexia and urinary retention the child regained movement in the left leg on July 8 and both legs on July 13 and passed urine spontaneously on July 23. He was moving both legs freely on Aug. 25. At the age of 1 year and 9 months the child was sitting up easily in bed, moving both legs and attempting to pull himself up by the cot rails. Ankle clonus had disappeared, the right plantar response was flexor, the left was extensor. In view of the anterior spina bifida noted in the 5th dorsal vertebra, special investigations were performed to establish whether the intraspinal mass arose in connexion with a corresponding mediastinal tumour. Radiological investigations with special reference to the mediastinum failed to reveal any tumour within the thorax.

FIG. 806.—Section through tumour showing cystic cavity surrounded by smooth muscle. At site A there is gastric mucosa and site B central nervous tissue, part of the central nervous tissue and not part of the tumour itself.

PATHOLOGICAL REPORT.—Dr. Iolo Williams reports as follows : The tumour on removal from the spinal cord was strawberry coloured and approximately oval in shape being 3½ cm. in its longest diameter and 1½ cm. in cross-section at its widest part (*Fig.* 805). On cut section it was cystic, with a white opaque irregular lining and a surrounding tissue of darker colour (*Fig.* 806). The fluid contained in the cyst and removed by aspiration during the operation was 20 ml. in volume and of an opaque milky appearance. Spun deposit of the fluid

showed the milkiness to be due to amorphous cellular debris and occasional leucocytes. There was no evidence of an inflammatory exudate and no tissue cells were demonstrated.

Histological examination showed the cystic space to be lined by upper alimentary epithelia which is thrown into folds in places and to be surrounded by smooth muscle with a mass of central nervous tissue at its margins but

FIG. 807.—Section of tissue from site A showing gastric mucosa with gastric glands containing oxyntic and chief cells. (× 72.)

mainly at one pole, the latter being probably part of the spinal cord and not a part of the tumour itself. The epithelia includes gastric mucosa with gastric glands containing parietal and chief cells (*Fig.* 807), stratified epithelium resembling that of the œsophagus, continuous with which there is some ciliated epithelium which is probably also œsophageal, the œsophagus during development being lined by ciliated epithelium (*Fig.* 808). The gastric mucosa contains superficial mucus-secreting columnar cells as shown by P.A.S. staining, with chief and parietal cells in the body of the glands. Hæmatoxylin and eosin stains show parietal cells with centrally disposed rounded nuclei and faintly eosinophilic cytoplasm of triangular appearance, one of the sides being related to the basement membrane. The chief cells are low columnar in type, with oval nuclei and a blue reticulated cytoplasm which tends to border the oxyntic cells, preventing their access to the lumen (*see Fig.* 807). There is no area of rapid growth or invasion in any part of the tissues studied. Serial sections through one half of the tumour show no evidence of any other heterotopic tissues. The tumour was originally considered to be a cystic intraspinal teratoma but the sections were submitted for consideration to Professor R. A. Willis. Professor Willis in a personal communication writes. "I doubt if this tumour is a teratoma; the diagnosis could only be sustained if sections of other parts showed other kinds of tissue. These tissues could well be due to a simple developmental heterotopia since they are indigenous to this particular level of the spinal cord. If I am right in supposing the lesion to be the result of a developmental dislocation of the alimentary canal it is strictly comparable with the entrocystomas and the rarer gastrocystomas of

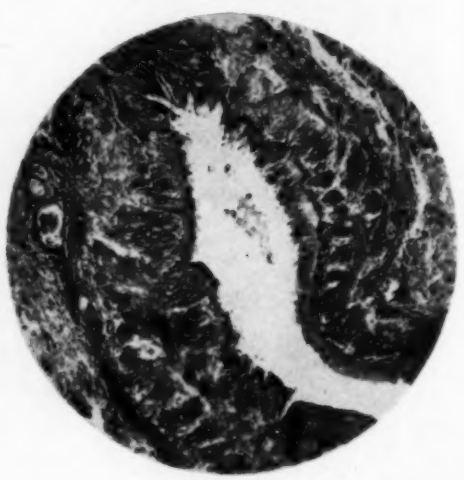

FIG. 808.—Section of tissue showing stratified epithelium resembling that of œsophagus continuous with which is ciliated epithelium. (× 72.)

the abdominal cavity and mediastinum. I do not know of any previously reported case of such a malformation in the spinal cord."

COMMENT

It is possible on theoretical grounds that the endodermal developing gut became nipped off before the fusion of the scleroderms. The ectopic gut growing within the neural canal would thus interfere with the development of the vertebræ at the same level, accounting for the abnormalities of formation of the vertebræ demonstrated in this case.

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INTESTINAL SARCOIDOSIS

By DAVID A. MACFARLANE, London

Early papers on sarcoidosis appeared by Besnier (1889), Boeck (1899), and Darier and Roussy (1904) describing various manifestations of the cutaneous lesions, although it was first recognized by Jonathon Hutchinson in 1898 and originally called ' Mortimer's malady ' after the patient concerned. Schaumann in 1914 pointed out that the skin manifestations were merely part of a systemic disease and gave it the name 'lymphogranulomatosis benigna '—to separate it from Hodgkin's disease—and described the inclusion bodies which now bear his name. A considerable literature on the subject has accummulated since that time, including the valuable papers by Ricker and Clark (1949) and Scadding (1950), but only one

Fig. 809.—Drawing of the specimen opened out to show the tumour in the ascending colon.

case of colonic sarcoidosis has appeared (Raven, 1949). It is therefore thought worth while to report the present case and to refer briefly to other intestinal granulomata and reticuloses.

CASE REPORT

E. H., a male aged 53 years, was admitted to St. James's Hospital, London, on July 25, 1953, with a history of periodic epigastric and right hypochondrial pain for thirteen years. The pain became worse on feeling hungry and there was food and alkali relief. There was occasional nausea, but no vomiting. He had had a poor appetite for years. There had been some gain in weight recently and he had no cough. The bowels were always regular, but latterly he had had occasional attacks of diarrhœa. There was no history of bleeding per rectum and there were no urinary symptoms. He had been investigated at two other hospitals in 1949 and 1953 and a duodenal ulcer diagnosed on barium X-ray examination. There were no other previous illnesses.

On Examination.—He was in good general condition. There was no anæmia. The cardiovascular and respiratory systems were normal. Blood-pressure 150–105 mm.

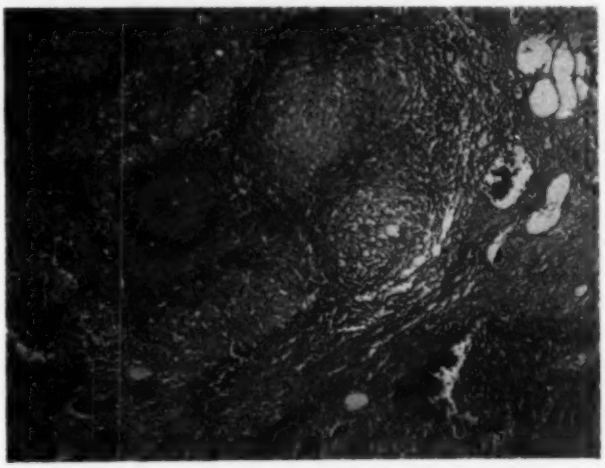

Fig. 810.—Photomicrograph of the tumour.

Hg. Examination of the abdomen revealed no physical signs and rectal examination was normal. There was no lymphadenopathy, but two small discrete skin nodules were present on the medial aspect of the right forearm 2 in. below the elbow.

At Operation.—On July 28 the abdomen was opened ; the stomach and duodenum revealed no ulceration, but the pyloric muscle was hypertrophically irregular. There were multiple stones in the gall-bladder. There was a bulky mass in the cæcum, with nodules in the adjacent peritoneum. The right colon was mobilized, the adjacent peritoneum and the right half of the colon and glands were removed, and this was followed by an end-to-end anastomosis of the ileum and transverse colon. The pyloric muscle was then transected and the mucosa seen to be normal. A biopsy was taken of the pyloric muscle and a Heineke-Mikulicz pyloroplasty performed. The gall-bladder was removed and the wound closed in layers. This was followed by a normal convalescence and discharge on the fourteenth post-operative day.

Radiograph of the bones of the hands post-operatively revealed no evidence of sarcoidosis. Mantoux test, 1-10,000 and 1-1000 were both negative. The patient was again seen in November, 1953, when he was well and symptom-free. Biopsy of the forearm nodules was requested, but unfortunately permission was refused.

The Specimen.—

Macroscopic Description.—The tumour does not appear to be a carcinoma. It is roughly circular, about 1 in. in diameter and 1 in. high, with an indefinite base and some adjacent mural thickening. The surface is fairly smooth and covered with mucosa (*Fig.* 809). Section shows an even mucosa overlying an œdematous submucosa with thickened subjacent musculature. The glands are fleshy and suggest granulomatous reaction.

Histology.—Sections of the tumour show small infrequent mucosal ulcers, submucous œdema, follicles

consisting of epithelioid cells with central giant cells, fibrosis, or fibrinoid necrosis. Mural fibrosis is a marked feature, with scattered sarcoid-like lesions, particularly at the serosal surface of the gut (*Fig.* 810).

Ten glands examined. Sections of the glands (*Fig.* 811) show the classical features of sarcoidosis, the normal architecture being replaced by œdema and multiple discrete pseudo-follicles composed of epithelioid cells in many instances associated with giant cells One or

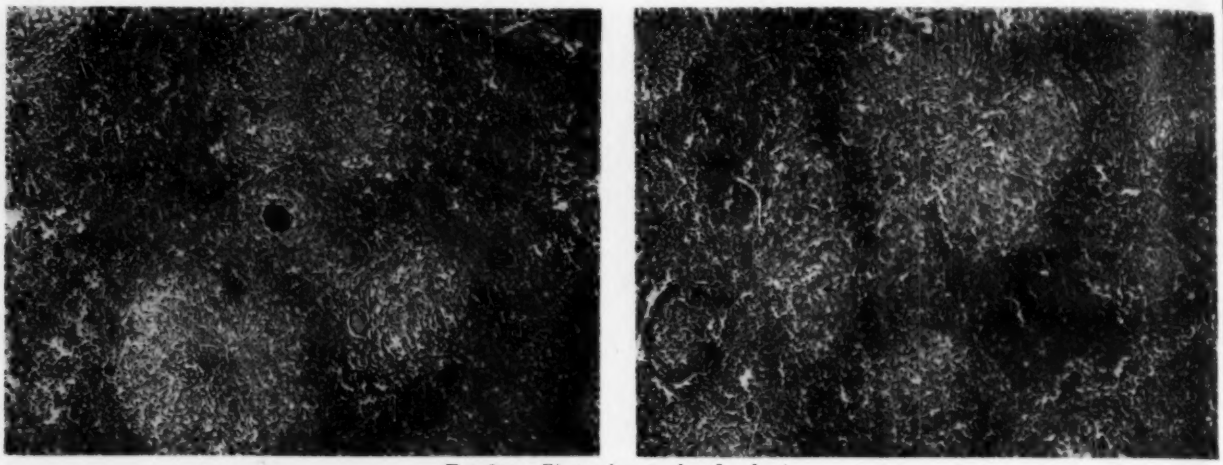

FIG. 811.—Photomicrographs of a gland.

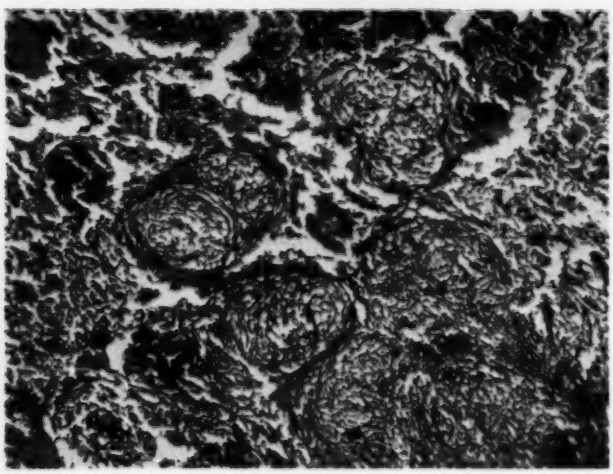

FIG. 812.—Photomicrograph showing persistence of reticulum fibres after silver impregnation.

two of the follicles show fibrinoid necrosis in the centre and/or fibrosis. Some giant cells show inclusion bodies. Silver-impregnated sections (*Fig.* 812) show persistence of reticulin fibres throughout the pseudo-follicles. There is no evidence of caseation, and prolonged search of many sections shows no tubercle bacilli.

CLINICAL

Sarcoidosis may manifest itself as a generalized state out of all proportion to the symptoms of the patient. Although it has a predilection for lymphoid tissue, almost all tissues of the body have at some time been described as affected. It is commonest in the 30–40 age group, with females being more often attacked. It may run a chronic course for a number of years and there may be marked periods of remission from symptoms. The general picture may be variable, with some fever, malaise, anorexia, drowsiness, and generalized aching pain, but usually no loss of weight. On the other hand there may be marked radiological changes in the lungs, with a complete lack of symptoms.

Locally there may be enlargement of lymph-node groups, and in every case at least one group is affected. The lungs are often involved, generally bilaterally, with multiple scattered foci; and emphysema may result from persistence of infiltration. Skin lesions may be present, of which three types are described; (*a*) multiple benign sarcoid; (*b*) subcutaneous sarcoid of Darier and Roussy; and (*c*) lupus pernio. There may be enlargement of the liver and spleen, and spontaneous rupture of the latter in this condition has been reported (James and Wilson, 1946). Iritis may occur with loss of vision and lacrimal, salivary, and cervical glandular enlargement has been reported as a Mikulicz syndrome (Macleod, 1952). Swelling more often than pain in the fingers and toes may indicate bony involvement, and the incidence of this is thought to be about 15 per cent. The radiological changes in the bones are those of a reticular pattern resulting from destruction of the finer trabeculæ. Punched-out cystic changes are sometimes seen in the phalanges. Dent, Flynn, and Nabarro (1953) point out that hypercalcæmia may occur and give rise to renal impairment and calculus formation.

McCarthy (1944) describes a case involving the stomach for which a gastrectomy was performed under the impression that the lesion was a malign one. Watson, Rigler, Wangensteen, and McCartney (1945) describe 2 cases of the small intestine where the clinical picture resembled Crohn's disease. Raven (1949) has shown that the condition arises in the colon, as he performed a right hemicolectomy for a case involving the ascending colon which presented with symptoms of obstruction. Gastro-enterological lesions are not commonly seen but may simulate a neoplasm, as in Raven's case and in the one quoted. Other organs in which the condition is recorded as being found locally include the pancreas, testicle, kidney, pituitary, heart, thyroid, breast, skeletal muscles, tendon-sheaths, optic nerve, and prostate gland.

Blood examination may be helpful in the diagnosis. There may be a mild anæmia or an increase in the monocytes, which may rise to 20 per cent or more, and in the eosinophils. The total serum-protein may be raised owing to an increase in the globulin fraction, and there is a reversed albumin-globulin ratio. The sedimentation rate is raised during the active phase, but these changes are not specific to the disease.

Radiographs of the lungs and of the hands and feet should be performed in all cases, as they may show a more advanced and generalized state than was anticipated.

Kveim (1941) described a test which he claims is specific for sarcoidosis. A suspension of sarcoid tissue derived from a proven sarcoid lymph-gland is injected into a patient with the condition to produce a slowly forming indolent papule. The delay interval of its appearance and its duration of many months are characteristic.

Biopsy of an enlarged lymph-node when present or of a superficial lesion is invaluable. Barium examination may reveal a filling defect or obstruction if the lesion is in the gastro-intestinal tract.

PATHOLOGICAL DISCUSSION

Little is known of the aetiology of the granulomata of the intestine apart from the lesions of amœbiasis, actinomycosis, and tuberculosis. Considerable research has been made into the aetiology and possible inter-relationships of intestinal tuberculosis, Crohn's disease, ileojejunitis, segmental colitis, and sarcoidosis without universally satisfactory conclusions being drawn; although nearly fifty years have passed since Whipple originally described his disease, the causative factors are still obscure.

Hadfield (1939) suggested that Crohn's disease might be a form of sarcoidosis, but Willis (1950) considers this a dubious comparison and it appears to have found little support elsewhere; he considers that it is probably an infection with the causative organism not yet identified. It has been reported after bacillary dysentery (Felsen, 1936), and Bargen isolated an organism said to be responsible for 90 per cent of the Mayo Clinic cases (Bargen and Brust, 1934). Bolton Carter (1953) mentions that anxiety states and emotional immaturity are often associated with Crohn's disease. Reichert and Mathes (1936) suggest that the cause is secondary infection of lymphœdema, and they produced the condition by injecting fine granules into the lymphatics, an experiment later performed by Chess, Chess, Olander, Benner, and Cole (1950) when they produced Crohn's disease in dogs by injecting fine sand.

In England it is thought most cases of sarcoidosis are the result of a peculiar reaction to the tubercle bacillus, probably from the passage of dead or moribund bacilli into the circulation, to give generalized lesions, but this is a view not held on the Continent (Macleod, 1952). Some postulate the presence of a filterable virus, a view to some extent supported by Kveim's test; others that it is a granuloma produced by a specific organism other than the tubercle bacillus. Some of the bone lesions resemble leprosy and the specific agent may be allied to the lepra bacillus but producing a form of granuloma different from tuberculosis and leprosy (Raven, 1949). Fungus infection has been suggested, and the granuloma from beryllium poisoning is similar in many respects. Those who oppose the theory that the tubercle bacillus is the aetiological factor point to the negative tuberculin test, the absence of tubercle bacilli when examined by the microscope, and the fact that a tuberculous lesion is not produced by guinea-pig inoculation with sarcoid. The negative tuberculin reaction may be due to a state of absolute immunity, and the tubercle bacillus difficult to demonstrate because it is of low virulence and has probably died where the typical lesion has appeared. Raven (1949) states that tuberculosis is the commonest cause of death in sarcoidosis, and suggests that a diminution of resistance of the patient may cause reactivation of the lesion.

There is little known of the macroscopical appearance of intestinal sarcoidosis, but its description has already been given in this case, and at operation Raven also mistook the lesion for cancer. The accepted histology is characterized by focal areas of large mononuclear cells of epithelioid type with occasional multinucleated giant cells. The epithelioid cells have abundant acidophilic cytoplasm and large ovoid vesicular nuclei. The giant cells are of the Langhan's or foreign-body type and may show inclusion bodies. Neutrophilic leucocytes and caseous necrosis are absent, but there are usually a few lymphocytes at the periphery, the whole being bound by a reticulum the fibres of which are demonstrable intact throughout the nodule. The foci may be isolated structures in normal tissue or arranged in groups or strands; they may resolve, remain stationary for months or years, may grow and fuse, or may heal to produce hyaline fibrous nodules, but the histological description is not specific for sarcoidosis.

There is no doubt as to the histological similarity of this group of diseases and that they could be tuberculous but for the absence of the tubercle bacillus in spite of the most searching efforts to find it; it is doubtful, too, if a negative Mantoux reaction can exclude a tuberculous aetiology in these cases. At operation the macroscopical picture has in the past and still does lead to a diagnosis of intestinal tuberculosis more frequently than is subsequently justified unless of course these syndromes are but manifestations or caricatures of tuberculosis. Classical terminal ileitis is usually confidently diagnosed at laparotomy, but Whipple's disease may be easily mistaken for tuberculosis, the glands in particular suggesting the aetiology; possibly the lipophagic activity of the glands and intestinal macrophages is fortuitous. In the case described and in Raven's case of intestinal sarcoidosis a confident diagnosis of carcinoma was made and operation proceeded with on this basis. The incidence of intestinal sarcoidosis is rare as judged by case reports, this being only the second discovered of the colon from a search of the literature, but it is likely that the diagnosis has been missed in the past. This, too, is the opinion of Watson and others (1945), who state " that there has been a general tendency in the literature to accept the giant cells and epithelioid cell tubercles often observed in Crohn's disease as evidence of foreign-body reaction often without apparent consideration of other possibilities such as sarcoidosis. A number of cases

described in the literature as due to foreign-body reaction may in fact represent an area of sarcoidosis. There is no reason why isolated sarcoid lesions of the intestine should not occur when one reflects upon the many other isolated varieties of the disease—bone, liver, spleen, etc." Cases of localized cutaneous sarcoid are also recognized. As post-mortems in cases of sarcoidosis are rare because of its relative benignity, one does not know how often the intestine may be involved in the generalized type. In the 2 cases which the above authors report they state that the diffuse and typical character of the epithelioid-cell tubercles in the mesenteric lymph-nodes is strong evidence of sarcoidosis. The exclusion of tuberculosis is essential in the diagnosis and the absence of caseation important. The impregnation of the reticulum with silver is an important differentiating point, as in sarcoid the reticulum across the centre of the tubercle is unaffected whilst in tubercle it is absent. Its presence in the case quoted is well shown in *Fig.* 812.

A very careful study of the natural history of sarcoidosis relating the pathological and post-mortem material with the clinical behaviour of the patient is undoubtedly required. The study of post-mortem specimens of patients with intestinal granulomata who die of unrelated diseases should be ardently pursued. Perhaps by such concentrated 'study series' relating clinical and pathological results, more would be found of the aetiology and inter-relationships of the various groups. Pathological examination of sarcoid material usually distinguishes tuberculosis from sarcoidosis, but the histological picture is similar to that of established regional ileitis, and perhaps the strongest evidence we have that the two clinical entities are unrelated is Crohn's belief that they are not the same disease, and, as Snapper (Snapper and Pompen, 1938) points out, the absence of generalized sarcoidosis in Crohn's disease.

TREATMENT

A proportion of patients suffering from sarcoidosis cure themselves, but general measures to improve resistance should be insisted upon in all cases. With this, as many as 50 per cent of those with pulmonary lesions may be cured. In others the condition may remain stationary; in some it would have appeared to progress and tuberculosis follow. Streptomycin and P.A.S. have been used without effect. Calciferol has helped some of the skin lesions in dosage of 50,000 units b.d. Irradiation of the lymph-nodes in the mediastinum has had some success, whilst more recently cortisone and ACTH have been tried, but it is too early to assess their effects. Where there is organic obstruction or pressure effects, especially in the gastro-intestinal tract, then surgery is indicated. Although only 2 cases of the lesion are recorded involving the ascending colon, right hemicolectomy was performed in each case and would seem to be the most satisfactory method of dealing with the lesion in that site.

SUMMARY

A pathological and clinical survey of sarcoidosis is presented together with a review of some of the literature. The similarity of the condition with other granulomata is discussed, illustrated by a case of sarcoidosis of the ascending colon. A plea is made for further study of the inter-relationship of these granulomata from the clinical and pathological aspect.

My thanks are due to Dr. Geoffrey Allen and Professor W. G. Barnard for the pathological report on the specimen; to my chief, Mr. Norman Tanner, for his help and kind permission to publish this case; to Dr. B. Morson for the photomicrographs; to Miss Mason for the remainder of the photographs; to Mrs. Mace for the drawing of the specimen; and to Dr. Geoffrey Allen for his help and constructive critism in the preparation of this paper.

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ACUTE ENTEROCOLITIS FOLLOWING PARTIAL GASTRECTOMY

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ACUTE enterocolitis as a complication of gastro-enterostomy was noted by Finney (1893) and later, by Terrier and Hartmann (1899) and Riedel (1902) following other operations. In a paper based on 5 personal cases the latter described a diphtheria-like membrane not due to Loeffler's bacillus. While commenting on its likeness to mercury poisoning, he showed that this could not have been the cause in his patients and inclined to think that it was due to pre-operative weakness and anæmia. More recently the literature has been reviewed by Penner and Bernheim (1939) and Dixon and Weismann (1948). The possible role of antibiotics has been discussed by Dearing and Heilman (1953), Reiner, Schlesinger, and Miller (1952), and Fairlie and Kendall (1953). A study of the case reports of these writers shows that a gross pseudomembrane was not always present and that this distinctive pathological feature is the result of a non-specific intestinal response to many forms of trauma such as bacillary dysentery, paratyphoid infection, uræmia, and following metallic poisons such as mercury (Bockus, 1944). The pseudomembrane formation which probably represents some degree of successful attempt at repair has been reported following a variety of surgical procedures and as a complication of entirely medical conditions. In the absence of membrane formation the post-mortem appearances are those of acute necrosis of intestinal mucous membrane, the destruction of the complete depth of which may only be evident on histological section. This form of acute enterocolitis bears a striking resemblance to the enteritis necroticans of many reports (Zeissler and Rassfeld-Sternberg, 1949; Beckermann and Laas, 1946; Heine, 1947; Hain, 1949). More recent accounts of the condition (Williams and Pullan, 1953; Bruce, 1953) are the first records we have been able to find from English writers, but it is doubtful if these reflect the true incidence of the complication.

MATERIAL

Personal experience of 8 cases of acute enterocolitis prompted a review of the notes of 1700 other patients who had had partial gastrectomy performed for simple peptic ulcer by two surgical units of the Queen Elizabeth Hospital during the past seven years. In this 1700 there were 35 patients who suffered from severe diarrhœa which began within eight days of operation and whose records were complete in respect of the number of stools passed and the treatment given. Others were excluded because of incomplete documents, and our figures therefore underestimate the incidence of the complication. Twenty-two of the 37 we classified as mild because, although the diarrhœa was severe (*Fig.* 813) and voluminous, no systemic upset resulted; no intravenous fluid replacement was called for and treatment was limited to increased oral fluids, with opiates or one of the antibiotics in some. Five patients showed clinical evidence of dehydration and were given intravenous fluids for one or more days. They may be regarded as a subacute group,

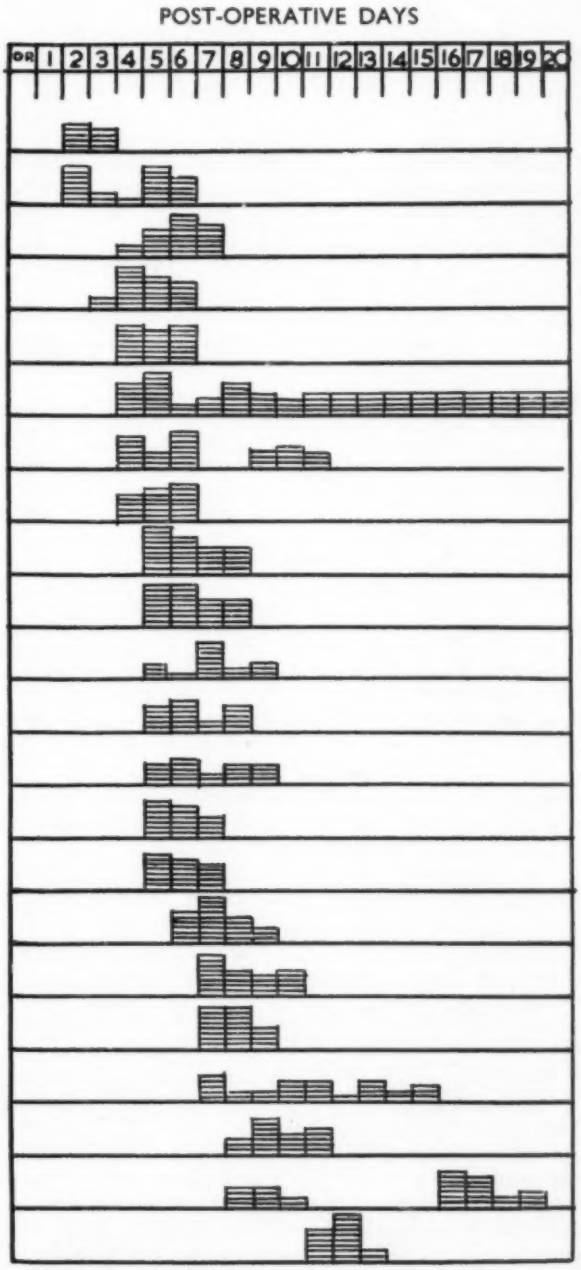

FIG. 813.—Showing day of onset and duration of diarrhœa in 22 cases, mild series. Each transverse line = 1 stool.

and it is noteworthy that their arterial tension and fluid balance were readily maintained by intravenous infusions of the order of four to five pints daily.

The remaining 8 patients belong to the group of acute enterocolitis. The number of stools, day of onset, and the antibiotics given are shown in *Figs.* 814 and 815. Five of this group died, a mortality-rate which underlines the severity of the condition.

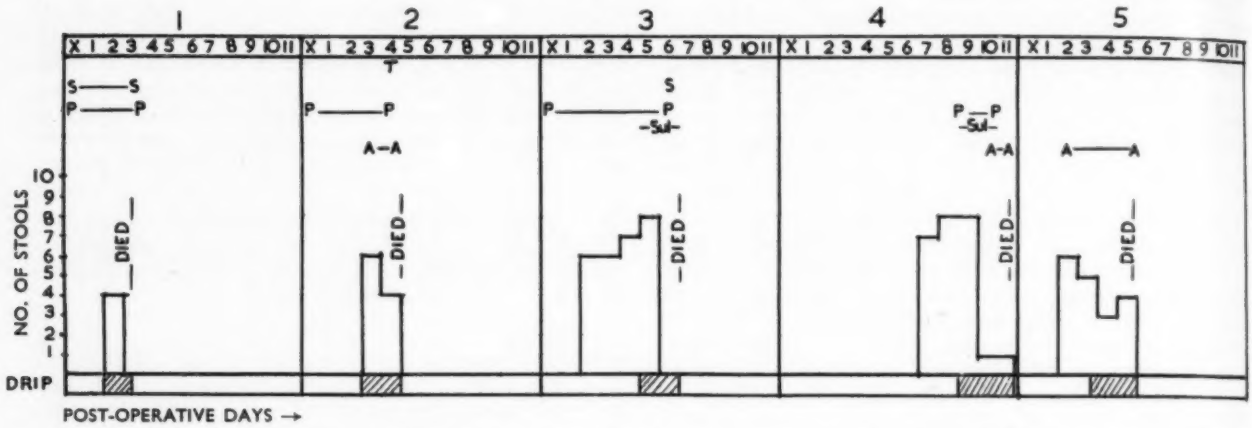

FIG. 814.—Showing onset, severity, and duration of diarrhœa in 5 fatal cases. Antibiotics given: P, Penicillin; S, Streptomycin; A, Aureomycin; Sul., Sulphathiazole, phthalylsulphathiazole, succinylthiazole; T. Terramycin.

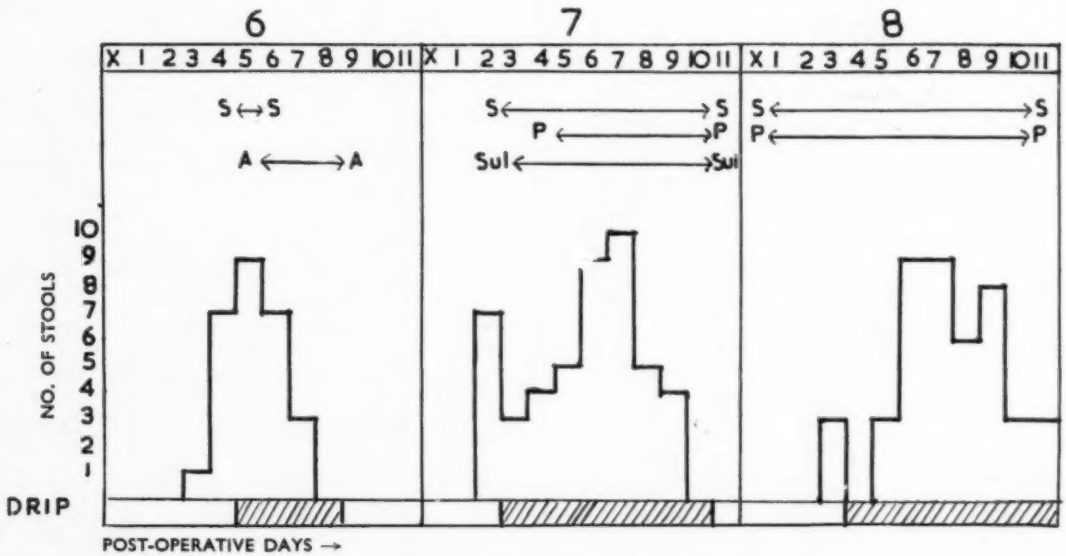

FIG. 815.—Showing onset, severity, and duration of diarrhœa in 3 cases that lived. Antibiotics given: P, Penicillin; S, Streptomycin; A, Aureomycin; Sul., Sulphathiazole, phthalylsulphathizaole, succinylthiazole; T, Terramycin.

CLINICAL FEATURES OF ACUTE ENTEROCOLITIS

Diarrhœa and circulatory collapse are the two salient features of the condition. Peripheral collapse may occur before diarrhœa, as happened in one of our series, and Hilsabeck and Dixon (1952) claim that in only 30 per cent of cases is there a voluminous sustained diarrhœa. The clinical course is divisible into two phases. For a period, which may vary from hours to days, depending on the severity of the attack and the supportive measures taken, the blood-pressure is maintained, and urine secretion continues. A pyrexia of 101° F. may be present with tachycardia. There is usually little indication at this point of the severity of the attack. The number of stools passed and their volume, while helpful in calculating the fluid and electrolyte requirements, have little prognostic value. In our experience a diminishing urine output is an ominous sign when associated with an apparently adequate positive fluid balance and normal arterial pressure. Patients in the mild and subacute group quickly show signs of improvement when the measured fluid loss is replaced; further deterioration towards a state of shock despite what would appear to be a reasonable fluid intake, is perhaps the first indication that the disease is of the severe type. Our experience leads us to the view that the second clinical phase, that of shock, with peripheral cyanosis, hypotension, anuria, fæcal incontinence, and mental disorientation, is preventable in most cases if adequate plasma and dextran infusion are given in good time. Characteristically, the hypotension is only slightly improved,

and for a brief period, by drugs such as methedrine, eucortone, and nor-adrenaline. In this state of collapse the patients may be incontinent, so that the volume of the excreta cannot be measured. Abdominal symptoms vary from attacks of colicky pain in the less severe cases to dull pain with scarcely audible bowel sounds. Auscultation of the abdomen confirms that bowel activity persists in nearly all patients for some period after the onset of diarrhœa and distension. Vomiting is not frequent in the early stages, but from the second day onward the gastric aspirate may be considerable and vary in appearance from bilious fluid to brown small-intestine content.

DIAGNOSIS

Pseudomembraneous colitis in clinical practice is a presumptive diagnosis unless confirmed by autopsy or unless the patient passes shreds of membrane. Its enormous mortality we believe to be due to tardy recognition. In the stage of shock, coronary thrombosis, embolism, or covert hæmorrhage may be suspected if the onset is dramatically sudden and diarrhœa absent or slight. A comparable picture may be presented by peritonitis, but fortunately some bowel sounds almost invariably persist and the gastric aspirate remains fresh. Gastro-enteritis due to bacterial contamination of food may cause difficulty if other patients in the ward or block are similarly affected, but diarrhœa from this cause is unlikely in the early post-operative period, when only bland fluids are being taken by mouth. In the phase of circulatory collapse, with frequent, incontinent stools, containing only the smallest particles of solid matter, the descriptive terms usually reserved for the algid stage of cholera (MacGraith, 1952) may apply.

The following case reports deal briefly with the relevant points from the histories of the 5 patients reviewed in this series who died of the disease. A full post-mortem examination was carried out in each case, and the gross pathological changes in the bowel are given in *Table II*.

CASE REPORTS

Case 1.—Male, aged 42. A Polya-type partial gastrectomy for chronic duodenal ulcer was performed on March 4, 1953. The operation was technically difficult owing to scarring of the duodenum and penetration of the pancreas by the ulcer. During the operation 1 pint of blood was given and on return to the ward a further 3 pints of intravenous saline glucose were administered by slow intravenous drip. Post-operatively his blood-pressure was well maintained; next day there were signs of a lobar collapse. Parenteral penicillin was continued and oral streptomycin commenced. On the second day, although the patient looked slightly cyanosed, with blood-pressure falling to 90/50 mm. Hg, in the forenoon, physical examination revealed no reason for this state. He complained of slight abdominal pain and following two loose stools his blood-pressure quickly collapsed. Death took place eighteen hours after the onset of the diarrhœa. His hypotension was unaffected by a further 1 pint of blood and 3 pints of intravenous fluid.

Case 2.—Male, aged 48. A Polya partial gastrectomy was performed on Oct. 27, 1952, for duodenal ulcer. The operation was technically easy. He was given penicillin from the day of operation for respiratory reasons and his oral fluid intake was augmented by rectal saline only. On the third post-operative day diarrhœa commenced, and within six hours his brachial blood-pressure was unrecordable, with a pulse-rate of 120 per minute. Intravenous plasma and Hartmann's solution were given with aureomycin by mouth. The blood-pressure remained low. On the fourth day his systolic pressure was estimated at 60 mm. Hg. Plasma and saline drips were continued and intravenous terramycin, nor-adrenaline, and ACTH given without effect on the patient's general condition. He died 40 hours after the onset of the diarrhœa.

Case 3.—Male, aged 42. A Polya partial gastrectomy for duodenal ulcer was performed on Nov. 24, 1950. Parenteral penicillin was given from the time of operation. This was uneventful and his post-operative progress appeared satisfactory until the second day, when following six loose stools only 2 oz. of urine were passed in the 24-hour period though the blood-pressure remained at 120/80 mm. Hg. Succinyl sulphathiazole with streptomycin was given by mouth. On the third day fluids by mouth were increased; the diarrhœa persisted and the blood-pressure dropped to 110/80 mm. Hg. On the fourth day the condition remained apparently good. Despite seven loose stools the blood-pressure was maintained at 110/80 mm. Hg. On the fifth post-operative day the blood-pressure was 90/50 mm. Hg and 2 pints of intravenous fluids were given for the first time, although he appeared to be in positive fluid balance, while on the sixth day the patient's blood-pressure became steadily lower despite a further 7 pints of intravenous fluids. He died four and a half days after the onset of the diarrhœa.

Case 4.—Male, aged 57. A Polya partial gastrectomy was performed on Aug. 10, 1950, for duodenal ulcer. His post-operative convalescence was complicated by prolonged bowel inactivity which ended on the fifth day with a spontaneous bowel action. A positive fluid balance was maintained up to this day by intravenous fluids. On the seventh day he passed seven diarrhœa stools followed by eight on the eighth day. Intravenous saline-glucose and Hartmann's solution were being given with parenteral penicillin and sulphaguanidine by mouth, but on the ninth day signs of peripheral vascular failure appeared. The patient became cyanosed, drowsy, and disorientated. His collapse was not affected by double-strength plasma and methedrine. Aureomycin was commenced. On the tenth day this treatment was continued without improvement in the hypotension. No urine was passed from the eighth day and the patient died four days after the onset of the diarrhœa.

Case 5.—Male, aged 60. This patient had a Billroth I type partial gastrectomy on Jan. 6, 1953, for stomal ulcer, following gastro-enterostomy fourteen years previously. His progress was satisfactory until the second day, when he passed six loose stools; and parenteral penicillin with oral aureomycin were commenced. This rate of diarrhœa continued with cessation of urine secretion and a progressive hypotension until on the third day his blood-pressure was 70/50 mm. Hg even though he had had 3 pints of plasma. During this day a total of 4 pints of plasma and 2 pints of Hartmann's solution was given. On the fourth day his blood-pressure persisted at about 90/60 mm. Hg, being maintained by double-strength plasma, dextrose saline, and nor-adrenaline. Treatment on these lines was continued, but he died on the fifth day, 72 hours after the onset of diarrhœa.

The sequence of events in the foregoing 5 patients depicts a clinical picture of diarrhœa followed by collapse which could not be accounted for by the *estimated* fluid loss.

The following 3 summaries deal with patients who, we submit, survived the condition by being

given relatively large quantities of intravenous plasma and other fluids.

Case 6.—Male, aged 67. A Polya Hoffmeister type partial gastrectomy was performed on July 3, 1952, for duodenal ulcer. On the third day three loose motions were passed and dihydrostreptomycin was given by mouth. On the fourth day the diarrhœa became worse, fluids by mouth were increased, and the blood-pressure and general condition remained good. On the fifth day intravenous fluids were commenced, 4 pints being given when the patient's condition became steadily worse until at midnight he had become cyanosed, disoriented, and incontinent, with an imperceptible radial pulse. At midnight a second intravenous drip was set up, when the systolic blood-pressure was 75 mm. Hg and the apical rate approximately 160 per minute. Using rubber syringe pressure on the bottles, 2 pints of reconstituted plasma and 1 pint of double-strength plasma were run in by a second drip within a period of two hours. At the same time a further 2 pints of glucose-saline were given via the original drip. The pulse-rate and blood-pressure were continuously observed during this period and in the end were: blood-pressure 110/70 mm. Hg, pulse-rate 120 per minute. Improvement was maintained from this point and the patient began to pass quantities of greyish-white membrane with each motion. The diarrhœa continued in lessening degree for a further three days but the blood-pressure was unaffected and fluid balance was easily maintained.

Case 7.—Male, aged 40. He had a Polya partial gastrectomy on Aug. 8, 1950, for chronic gastric ulcer. On the second day following the onset of acute diarrhœa he suddenly collapsed, with systolic blood-pressure varying from 55 to 80 mm. Hg, the diastolic being unrecordable. Intravenous glucose-saline was given with eucortone and phthalyl sulphathiazole, the total fluid intake for this day being 7200 ml. orally and intravenously. On the third day, with continued intravenous drip, and total intake 7000 ml., the blood-pressure steadily recovered to 110/70 mm. Hg. Phthalyl sulphathiazole and streptomycin were given from the second day and penicillin from the fourth day, by which time the pulse-rate and blood-pressure had returned to normal. The diarrhœa persisted for six more days, the number of stools varying from six to ten daily, but the patient recovered.

Case 8.—Male, aged 58. A Polya gastrectomy was performed on March 18, 1953, for chronic duodenal ulcer. His progress gave no indication of anything being wrong until the third post-operative day, when his temperature became 101° F., and his pulse-rate increased to 110. He felt sick, and on passing a Ryle's tube, 900 ml. of bile-stained fluid were aspirated. The blood-pressure was 120/80 mm. Hg. One fluid motion was passed at mid-day. Plasma and Hartmann's solution were given by intravenous drip to a total of 4200 ml. On the fourth day another diarrhœa stool was passed and 3600 ml. of fluid were given intravenously. With these measures the blood-pressure was maintained, although he continued to have colicky abdominal pain. Intravenous fluid was continued at an average of 3600 ml. per day, as the number of loose stools increased to nine on the sixth day, most of them incontinently. The number of motions diminished to three on the ninth day, by which time 20,500 ml. of intravenous fluid had been given. Fluid balance of this patient was carefully controlled, and despite the apparently large positive balance his blood-volume was found to be about 900 ml. below normal on the seventh day (Evans' blue method). This volume deficiency was restored by 2 pints of plasma, with a coincident lowering of his venous blood hæmatocrit from 37 per cent to 32 per cent. Subsequent progress was uneventful.

TREATMENT

The high mortality from pseudomembranous colitis is partly due to late diagnosis consequent on its comparative rarity. In this series its incidence is 0·5 per cent following gastrectomy and there is only one other recorded in 2840 autopsies performed in this hospital during the same period. Restoration of the blood-pressure by intravenous replacement therapy before renal damage or a state of irrevocable shock occurs, is the basis of treatment. We have found that plasma or dextran with saline are more effective than saline alone, and that it should be administered at a rate which may seem heroic by ordinary standards, until the blood-pressure rises and clinical improvement is evident. Dearing and Heilman (1953) report one instance of 4400 ml. fluid loss in the stools in a 24-hour period and estimated a total loss by all routes of 16,805 ml. Hilsabeck and Dixon (1952) gave to one of the earliest patients treated successfully 2880 ml. of fluid intravenously within a space of some minutes, thereby causing the blood-pressure to improve from 80 mm. to 110 mm. Hg systolic. In our *Case* 6 a measurable brachial pressure followed 2500 ml. of fluid given in a 2-hour period, while Williams and Pullan (1953) record one patient's recovery from a state of advanced circulatory collapse following approximately 11 litres of intravenous fluid given in a 24-hour period. When diarrhœa precedes clinical evidence of shock it is impossible to predict whether its course will be mild or severe, and particularly when this happens in the first few post-operative days the maintenance of a positive fluid balance by intravenous drip becomes most essential, so that the first signs of deterioration towards a state of shock may be countered by fluid replacement. The amount of fluid required may be controlled by careful observation of the blood-pressure, the urinary output, and the clinical state of the patient.

Overtransfusion as a complication of massive and rapid intravenous therapy should not occur with careful supervision.

Culture of the stools has rarely been helpful because of the unavoidable delay in identifying organisms and assessing their sensitivity. Blood- and plasma-volume estimations are rarely feasible, but repeated hæmatocrit readings give useful information where large amounts of fluid are being lost and replaced. It seems reasonable to give oral and parenteral antibiotics, such as aureomycin, with a wide bacterial range, but if antibiotics have already been given it is probable that any organisms present are resistant, and while the results of sensitivity tests are awaited, a change of drug is indicated. In many cases examination of the stools fails to identify a pathogenic organism.

Vasoconstrictor drugs have little place in the treatment unless perhaps as an adjunct to adequate fluid replacement.

LABORATORY AND POST-MORTEM FINDINGS

Laboratory investigations of the stools included microscopical examination of fresh film stained by Gram's method and culture. Aerobic cultures were grown on MacConkey, Leifson, and Wilson

and Blair media, and also with tetrathionate and selenite enrichment technique. An aerobic culture was carried out on blood-agar and meat broth, *Clostridium welchii* type F (Zeissler and Rassfeld-Sternberg, 1949) being particularly looked for on some cases.

Table I.—Result of Bacteriological Examination of Stools

	Nil Carried Out	Nil Abnormal Found	Pus	R.B.C.	Organism
Acute	2	4	2	Staphylococcus	(1)
				Pyocyaneus	(1)
Subacute	2	3	—		
Mild	8	8	6	Enterococci	(1)
Total	12	15	8		

Except in *Case* 6, where a heavy growth of *Staph. pyogenes* resulted, and in *Case* 8, from whom *Ps. pyocyanea* was grown, the usual findings (*Table I*) were mixed coliform organisms and some enterococci. In *Case* 2 stained films and cultures were prepared from pulped jejunum at autopsy. These cultures also resulted in a growth of coliform organisms and enterococci, cultures prepared from the liver and spleen being negative after 72 hours. Stained films, however, showed a large number of bacteria, both Gram-negative and Gram-positive, in fluid from the jejunum—a site where the bacterial population is normally very small (Cregan, Dunlop, Hayward, 1953). At post-mortem examination no membrane was present in 3 patients (*Table II*). Instead, the bowel, which externally had a normal or slightly hyperæmic appearance, was found on examination of the lumen to be thickened, the mucous membrane being intensely congested and red or purple in colour. Gross ulceration of a patchy distribution was seen in one or two cases (*Figs.* 816, 817). The volume of fluid in the bowel varied from 1000 ml. to almost none.

PATHOLOGICAL FINDINGS

The gross appearance of the bowel is characteristic and was described by Riedel (1902) as " diphtheria of the bowel not due to Loeffler's bacillus but to necrosis of the mucous membrane ". This membrane, greyish-white in colour, may occur in patches with apparently normal or slightly reddened but intact epithelium in between, or may affect long stretches of the small or large bowel continuously. In places the absence of membrane exposes small areas of superficial ulceration with non-ulcerated segments presenting a dark-blue or reddish-blue hyperæmic appearance. Œdema of the wall of the affected segment is usual and in one of our cases, where very little membrane was present, the œdema was very marked. The greyish membrane can be readily stripped off, carrying with it a varying amount of underlying epithelium, and sometimes it is found lying between the folds of the mucous membrane. Perforation has been recorded and some stenosis of bowel may be demonstrable in survivors. The membrane and the epithelial necrosis is commonest in the small and large bowel though it has been described in the œsophagus and stomach (Dixon and Weismann, 1948).

Table II.—Showing Gross Post-mortem Appearances and Site of Membrane Formation in 5 Fatal Cases

	Stomach and Duodenum	Jejunum		Ileum		Colon	Rectum	Peritoneal Cavity
		Upper	Lower	Upper	Lower			
1	Nil	Grey membrane		Patchy grey membrane	Detached membrane with ulcers	—Nil—		Dilated ileum and jejunum
2	Nil	Increasing congestion	Patchy greenish membrane	Patchy orange membrane	Less severe	Uniform grey membrane separating, leaving patchy ulceration		Dilated jejunum
3	Nil	Increasing congestion and œdema	Fibrous threads becoming patchy membrane	Completely covered with yellow adherent membrane				Brownish exudate with flakes of fibrin
4	Nil	Intense congestion and hyperæmia but no membrane formation						Distended jejunum and ileum
5	Nil	Severe hyperæmia and œdema	Less severe congestion	Severe hyperæmia and œdema		Patchy ulceration over whole length, with necrosis of mucosa. Intervening mucosa œdematous		Distended small bowel

Histology.—Microscopical examination reveals that the diphtheritic-like membrane consists of fibrin and amorphous exudate containing leucocytes and erythrocytes resting on the remains of the mucous membrane or on the submucous layers. Numerous bacteria are present from which on culture *Escherichia coli* and staphylococci may be grown. In a careful study based on the histological appearances of 7 cases of pseudomembranous colitis, Reiner, Schlesinger, and Miller (1952) distinguish between ' simple ' or surface pseudomembrane and ' compound ' pseudomembrane where there is stromal necrosis which may extend down to or beyond the muscularis mucosæ. Obviously, healing following ' simple ' membrane formation results in no distortion of the normal pattern and leaves no trace. Healing of the deeper variety is by sequestration of the membrane and glandular loss is permanent—

the resulting mucosa being thinner than the normal. Complete regeneration of the epithelium does, however, take place and ulceration does not persist.

Hyperæmia and œdema of the submucous layers is a regular feature with dilatation of the mural

FIG. 816.—Colour print showing ulceration and mucous membrane formation in the small intestine.

blood-vessels. Scattered points of focal hæmorrhage occur, and polymorphs, macrophages, and lymphocytes can be recognized with numerous bacteria, particularly in the submucous layers (*Fig.* 818). Generally the muscular layer tends to be least affected and may only show hyperæmia and œdema.

DISCUSSION

The cause of acute pseudomembranous colitis is not agreed. Earliest writers blamed such things as mercury (Riedel, 1902); putrefaction in the intestines of an undernourished patient (Auschütz, and Grenzbeg, 1905); medicated enemas (Wertheim, 1911); while Penner and Bernheim (1939) regarded the condition as the result of vasoparalysis. The theory that the condition is a sequel of shock is supported by the experimental work of Gesell (1919) and Blalock and Levy (1937). Gesell postulates that compensatory vasoconstriction may be such as to reduce the blood-flow below that essential for normal nutrition and that when this happens areas of focal necrosis and inflammation result. Dixon and Weismann (1948), however, in an analysis of 23 cases, found evidence of shock occurring in the post-operative period only in 1 instance—always developing, however, after the onset of the intestinal complication. In the 10 cases reported by Williams and Pullan (1953) a state of shock during the operation period was noted in 2 patients only. Reiner, Schlesinger, and Miller (1952) conclude that the condition may follow aureomycin or chloramphenicol medication, but were not able to demonstrate any intestinal pathogen or fungus in 7 patients. More recently, Dearing and Heilman (1953) have shown that after the administration of terramycin or aureomycin the presence of resistant strains of micrococci in more or less pure culture may be demonstrated in patients with mild or very severe gastro-intestinal and systemic symptoms. These micrococci cannot be held entirely responsible, and their presence may perhaps merely accentuate the symptoms. They note that in a ten-year period before antibiotics were available the records of the Mayo Clinic contained 42 deaths from pseudo-membranous colitis, and in the ten years after 1943 there were 37 similar deaths. *Micrococci pyogenes* (staphylococci) were not present in all cases, but their elimination by erythromycin improved the gastro-intestinal and systemic state in all patients to whom it was given. Editorial comment (*Gastroenterology*, 1952, **21**, 453) suggests that many cases of diarrhœa are due to destruction of the ordinary bacteria and their replacement by moulds and resistant forms of staphylococci. More recently, Fairlie and Kendall (1953) were able to grow pure cultures of hæmolytic *Staph. aureus* from the bowel contents of 5 patients who died of enteritis and who had been given penicillin and dihydrostreptomycin intramuscularly. Williams and Pullan (1953) likewise found *Staph. aureus* on culture of the stool or bowel content in 4 out of 7 cases. Fatal enteritis due to non-hæmolytic streptococci and *Staph. aureus* insensitive to antibiotics previously administered, is recorded by Wakefield and Somers (1953). The role of specific organism, however, in the causation of acute enteritis is difficult to evaluate. There is evidence that the exhibition of antibiotics is sometimes followed by the growth of resistant strains of bacteria in the bowel presumably due to disturbance of the normal flora.

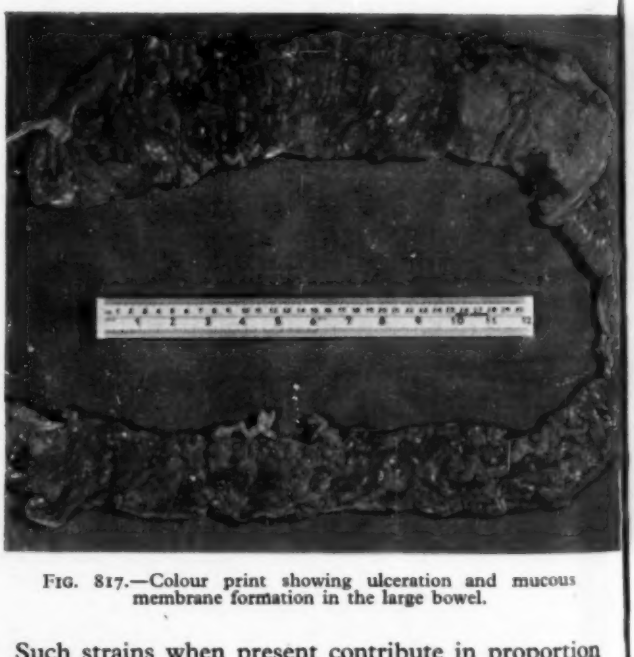

FIG. 817.—Colour print showing ulceration and mucous membrane formation in the large bowel.

Such strains when present contribute in proportion to their virulence to the toxæmia, but in some patients stool cultures are negative and in many no antibiotics were given.

COMMENT

Detailed consideration of the clinical records of this series, while readily excluding many recognized

causes of acute diarrhœa, has not been helpful in deciding such controversial points as the part played by pathogenic organisms and the importance of oral and systemic antibiotics. Length of stay in hospital before operation bore no correlation to the severity of enterocolitis when it occurred or to the organisms isolated from the stools. The factors common to all cases were a major surgical procedure involving the alimentary tract, with consequent restriction of food and fluid by mouth for some days, plus a varying period of intestinal stasis. A post-operative intake of 1 oz. hourly rising to 4 oz. and supplemented by rectal or intravenous fluid of the order of 2–4 pints daily may find the patient in a considerable fluid deficit at the end of the second post-operative day. Coincident and unsuspected loss of fluid either into the bowel wall or lumen may bring him to the limit of his powers of compensation before diarrhœa appears, and may explain the indifferent response to nor-adrenaline and other vasoconstrictors at this stage. Indeed, circulatory collapse in the early post-operative period, for which an adequate explanation is not immediately evident on examination, should cause the syndrome of acute enterocolitis to be considered.

The most effective therapeutic measure available to us in acute enterocolitis, whether presenting as diarrhœa or circulatory collapse, is replacement of the deficit in the circulatory fluid volume at a rate which is controlled by the blood-pressure and general condition of the patient. Should bacteriological examination of the stools reveal pathogenic organisms, the appropriate antibiotic is then given in the amounts indicated by sensitivity tests.

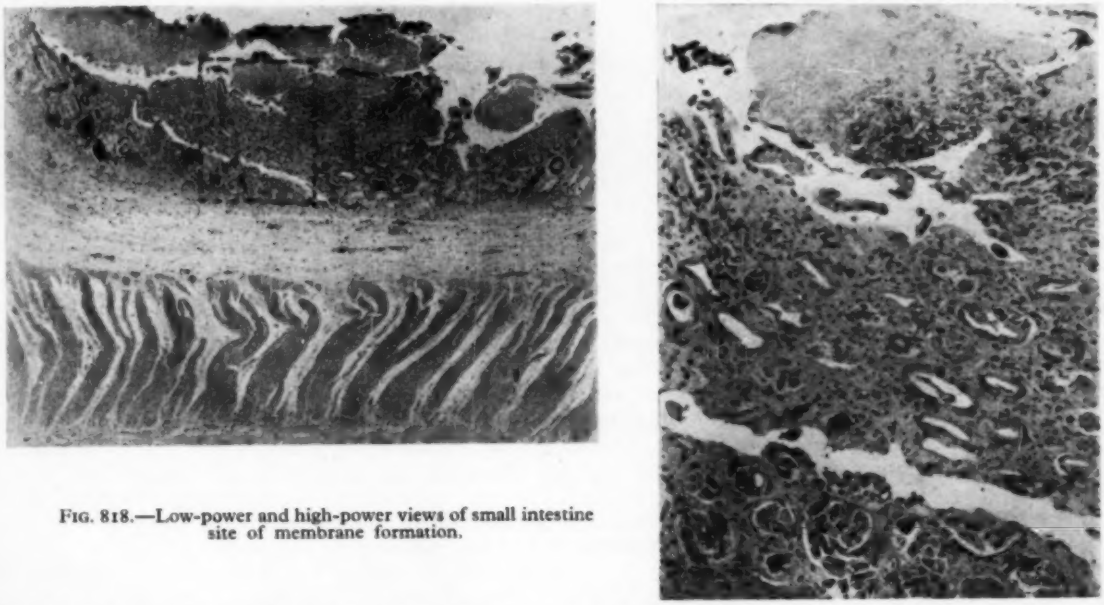

FIG. 818.—Low-power and high-power views of small intestine site of membrane formation.

SUMMARY

1. The case records of 1700 patients who had undergone partial gastrectomy for peptic ulcer have been reviewed, and the notes on 35 patients suffering from post-operative diarrhœa have been analysed.

2. Pathogenic organisms were demonstrated (*Staph. aureus*, 1; *pyocyaneus*, 1) in 2 cases.

3. In 5 fatal and 30 non-fatal cases no relationship to antibiotic therapy could be demonstrated.

4. In this hospital, fatal results from acute enterocolitis have only been seen following partial gastrectomy.

5. The clinical features of enterocolitis, and particularly the tendency to early peripheral circulatory failure, are due, in our opinion, almost entirely to depletion of the circulating fluid volume.

6. The importance of early diagnosis where collapse is imminent is stressed, and we are in agreement with the views of those who hold that rapid fluid replacement is most important in treatment and for this purpose plasma is probably the most effective substance.

We have much pleasure in thanking Mr. R. P. Scott Mason, Professor F. A. R. Stammers, Mr. Arnold Gourevitch, and Mr. Bryan Brooke for access to their case records of these patients in making this review. Also the late Dr. A. L. Peeney for carrying out all the bacteriology involved, and Professor J. W. Orr, of the Department of Pathology, Birmingham University, for his help in interpreting the histopathology.

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SQUAMOUS-CELLED CARCINOMA OF THE BREAST

BY T. G. I. JAMES AND C. TREIP, LONDON

IN making the histological diagnosis of squamous-celled carcinoma of the breast, care is necessary to avoid confusion with solid undifferentiated carcinoma (medullary carcinoma) in which the cells are often flat, polygonal, and bear a superficial resemblance to squamous cells. True squamous cells are distinguished by two features, either or both of which should be present—intercellular bridges (prickle-cell formation) and keratin formation. In a largely anaplastic tumour, many, perhaps the majority, of the cells will show neither of these features, and careful search through many sections may be necessary to demonstrate an unequivocal squamous formation.

Judged by these rigid criteria, squamous-celled carcinoma of the breast is a rare tumour. Willis (1953) gives an incidence of 1 per cent of surgically treated cases; Foot and Moore (1938) give an incidence of 0·5 per cent. Johnson and Lawrence (1917) described 2 cases, Deaver and McFarland (1917) reported 4 cases, and Stout (1932) a similar number. Haagensen (1933) found 2 squamous-cell cancers among 164 mammary carcinomas.

CLASSIFICATION AND HISTOGENESIS

Geschickter (1945) considers that squamous-celled cancers in the breast may arise in four different ways: (1) From epidermoid cysts undergoing malignant change; (2) By squamous-cell metaplasia with malignant change in fibro-adenomas; (3) As nests of squamous cells in medullary carcinomas; (4) As squamous-celled carcinoma arising from the epidermis of the areola or skin overlying the breast.

Epidermoid Cysts.—The view of epidermoid cystic origin is based on Cohnheim's theory of displaced cell-rests, and was upheld by Wilms and many others of lesser eminence. The breast, being a modified sweat gland, is an ectodermal organ, and it is supposed that during development an epidermal bud becomes displaced into the deeper tissues, later to develop cystic or malignant properties. Geschickter is of the opinion that dermoid cysts in the breast are more prone to malignant change than similar cysts elsewhere in the body; he gives an incidence of malignancy of 1·3 per cent among dermoid cysts of the neck, whereas in the breast there were six malignant cases among a total of 34 (17 per cent). He also states that the degree of malignancy is low, only one of the six in his series dying from metastases. Menville (1936), however, gives an incidence of malignancy of 19 per cent and states that these carcinomas metastasize early. These tumours are recognized by their cystic character, pultaceous contents, and the epidermal lining with keratinization found histologically. The incidence of this type of tumour in the literature is extremely low. Pasternack and Wirth (1936) found 4 cases of carcinoma among their references to 'cholesteatoma' (the name given to epidermoid cysts undergoing liquefactive degeneration).

Squamous Metaplasia.—Squamous metaplasia has been reported in the ducts and glandular cells of fibro-adenomas of the breast (Grohé, 1900; Pasternack and Wirth, 1936; Oliver, 1940). This metaplasia is thought by some to be due to prolonged stimulation by œstrogens. Geschickter points out that squamous-cell metaplasia is often noted in œstrogenic mammary carcinoma in the rat, and Pasternack and Wirth mention that physiological squamous metaplasia of large ducts occurs during pregnancy.

Medullary Tumours.—The third group (squamous cells scattered throughout medullary carcinoma) is vaguely defined by Geschickter (1945), who himself admits that the cells of these tumours may be confused with true pavement epithelium, and that typical pavement epithelium with keratinization was found by him in only 4 cases. The medullary cells should be readily distinguishable under the microscope from the true squamous cells, and therefore it is unlikely that cases in this group would present any difficulty.

Squamous-celled Carcinoma arising from the Skin.—This is the rarest of the four groups; it is commoner in the male breast and moreover is not a true tumour of the breast itself but of its integument. It is, therefore, not proposed to include these in the present discussion.

Recently 2 cases of squamous-celled carcinoma of the breast have presented themselves at the Central Middlesex Hospital. They represent the only 2 cases seen in a series of 500 cases of breast tumours.

CASE REPORTS

Case 1.—A single woman, aged 51 years, was admitted complaining of a painless lump in the right breast, first noticed six weeks previously, when it was the size of a

bean. Rapid growth had occurred in the past three weeks. No other lumps had ever been noticed in that breast. General examination revealed no other lesion and radiography of the lungs showed no abnormality.

On examination of the breast there was a spherical tumour, 12 cm. in diameter, occupying almost the whole of the right breast. It was cystic and mobile on deeper structures. The overlying skin was slightly red and warm, but not attached to the tumour. No enlarged axillary lymph-nodes were palpable. Needle aspiration yielded dark-brown fluid mixed with pultaceous white material.

A wide excision of the breast only was performed. The specimen removed showed, on section, a cavitating growth, 12 × 10 cm. across, with a necrotic, pink, and

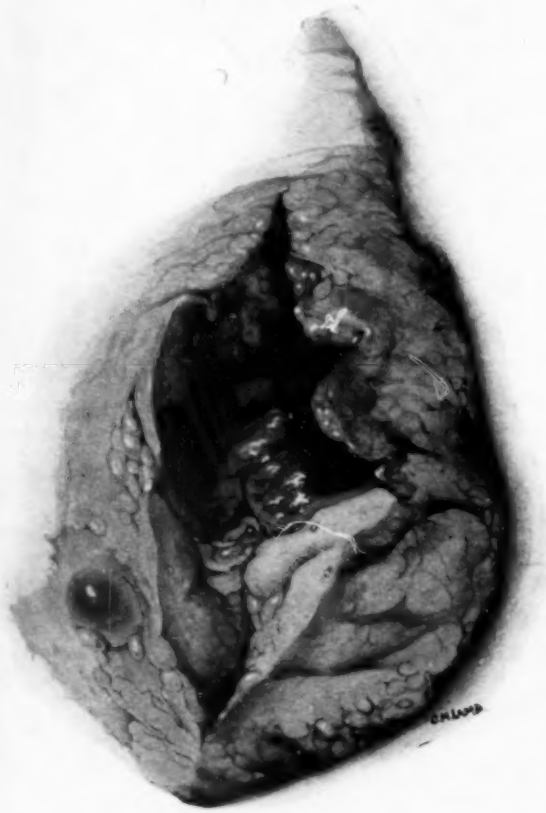

FIG. 819.—*Case* 1. Painting showing the cavity of the tumour (undersurface of breast).

yellow lining (*Fig.* 819). Section showed it to be deeply situated well away from the skin (*Fig.* 820). Microscopy showed an extensive, cornifying, squamous-celled carcinoma, some of the keratinized cells showing bizarre nuclei and atypical mitoses, such as one sometimes sees in anaplastic squamous-celled carcinoma elsewhere (*Fig.* 821). Some parts of the tumour showed obvious squamous metaplasia in the ducts and acini (*Fig.* 822). There were several areas blending with the squamous growths which appeared to be ordinary polygonal-celled, non-squamous carcinoma (*Fig.* 823). Adjacent to the tumour the breast showed cystic mastopathy. There were large areas of necrosis in parts of the tumour and areas of fat necrosis in some parts of the breast which were free of growth. The grade of malignancy appeared to be high.

The patient recovered satisfactorily and was discharged after receiving a course of radiotherapy. She was re-admitted three months later with enlargement of some of the axillary lymph-nodes on the right side. The axilla was cleared of a mass containing many enlarged lymph-nodes up to 2 cm. in diameter. Microscopy showed squamous-celled carcinoma of variable differentiation, some areas being highly differentiated and cornifying, others being markedly anaplastic, with bizarre mitotic

FIG. 820.—*Case* 1. Vertical section showing the growth to be well away from the skin surface. (× ⅘.)

figures and giant-cell forms. The patient was discharged for further radiotherapy. She was re-admitted six weeks later with metastases in the lungs, right-sided pleural effusion, and extensive and generalized cutaneous metastases. She died one week later.

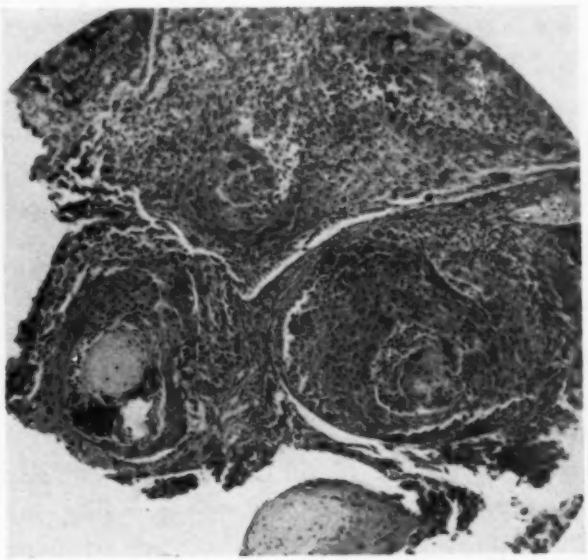

FIG. 821.—*Case* 1. Keratinized cell nests of carcinoma. (H. and E.) (× 60.)

Post-mortem examination (P.M. No. 54/66) showed the body of a wasted middle-aged woman. There were many nodules of growth, some ulcerating, in the region of the operation, and a marked subcutaneous infiltration of the right axilla and across the front of the chest into the left breast. The sternum and right ribs were invaded by growth, the sternum showing a pathological fracture. The tumour had extended directly into the right thoracic cavity, where it was fungating freely on the parietal pleura. The right pleural sac contained 1 litre of blood-stained fluid. Both lungs contained nodules of growth,

both in the parenchyma and in the hilar lymph-nodes, up to 2 cm. in diameter. Solitary nodules of growth were present in the apex of the left ventricle, the ileum on the mesenteric border, about 50 cm. from the duodeno-jejunal flexure, and the left suprarenal gland. The liver and both kidneys contained multiple nodules of growth. The brain was free of metastases.

Histologically, the metastatic growths showed a structure similar to that of the primary growth—a mixture of squamous-celled and alveolar spheroidal and polygonal-celled carcinoma, the squamous element predominating.

Case 2.—A single woman, aged 52, had noticed a painless swelling in the left breast for five weeks. On examination, there was a firm swelling, 9 × 10 cm., in the inner and upper quadrant of the left breast. The nipple was not retracted but the skin was fixed to the mass and discoloured. The mass was attached to the deep fascia. A large, hard lymph-node was felt in the left axilla. No other enlarged nodes were palpable and no abnormal physical signs were found elsewhere.

A radical mastectomy was performed. Enlarged lymph-nodes were found over the clavipectoral fascia and in the left axilla. These were cleared. The specimen showed a solid, greyish tumour of hard consistency, deep in the breast and unconnected with skin, 6 × 6 cm. on section, the gross appearance being that of a scirrhous carcinoma, but perhaps rather more sharply defined against the breast tissue. Microscopy showed a tumour which, in some areas, resembled a spheroidal-celled, medullary carcinoma, the cells being large and pale, with vesicular nuclei and numerous mitoses. Other areas showed differentiation to squamous epithelium (*Fig.* 824) with prominent intercellular bridges (*Fig.* 825). No keratinization was seen. Transition between squamous and non-squamous areas was in some places sharp, others imperceptible. Section of a large axillary lymph-node showed extensive solid carcinoma of the medullary type, with some cells of a pavement-like appearance, but without true squamous differentiation. The grade of malignancy seemed to be high. The patient was discharged after X-ray therapy and was well when seen six months later.

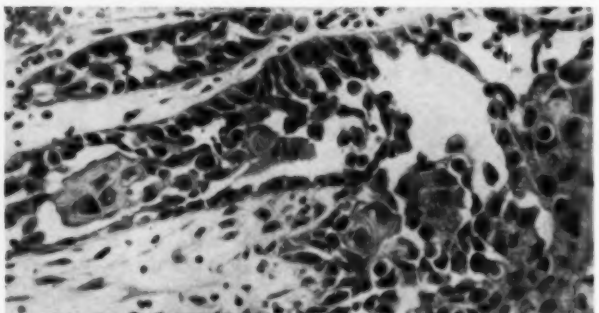

FIG. 822.—*Case* 1. Squamous metaplasia of ducts. (H. and E.) (× 200.)

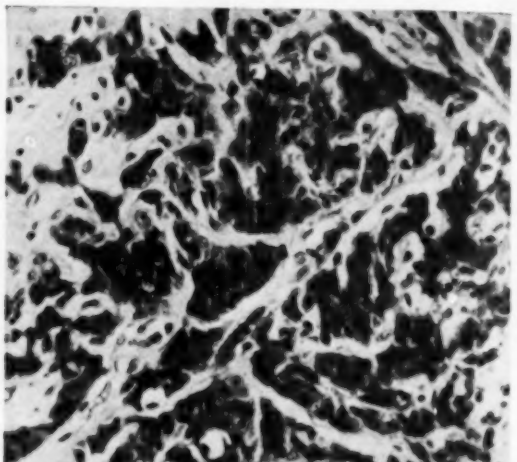

FIG. 823.—*Case* 1. An area of non-squamous medullary carcinoma. (H. and E.) (× 200.)

FIG. 824.—*Case* 2. Clumps of squamous cells merging with medullary carcinoma. (H. and E.) (× 96.)

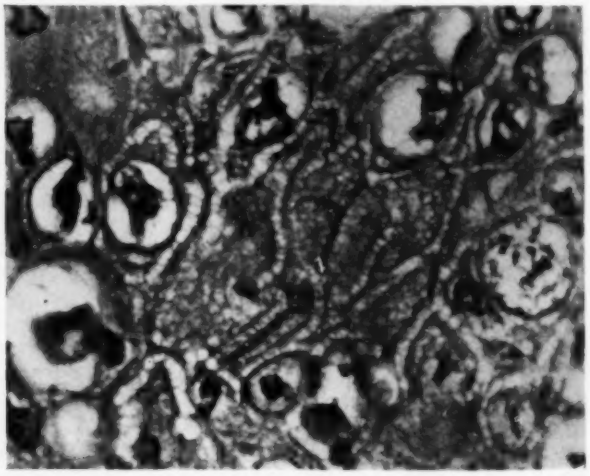

FIG. 825.—*Case* 2. High-power view of squamous cells to show intercellular bridges. (H. and E.) (× 470.)

DISCUSSION

The interest of these tumours lies in their possible histogenesis, as well as in their rarity.

Case 1.—The view that ' cholesteatomas ', with or without malignant change, arise from displaced

epithelial cells, in accordance with the Cohnheim theory, is open to serious criticism. Much has been written opposing this theory of the cell-rest (i.e., congenital) origin of tumours, and Nicholson's (1923) devastating attack on the Cohnheim theory has yet to be seriously challenged. In our case the gross appearance of the tumour accorded fully with earlier descriptions of ' cholesteatomas '. The most significant points in the histology are the obviously metaplastic epithelium of the ducts and of some acini, and the areas of non-squamous polygonal-celled carcinoma resembling ordinary carcinoma. These two facts point to the probable metaplastic nature of the tumour.

It is perhaps of interest to compare this tumour with the 4 cases, cited by Pasternack and Wirth (1936), of ' cholesteatomas ' undergoing malignant degeneration. Lahm (1914) described the case of a nullipara, aged 34, who complained of a gradually enlarging lump in the right breast of six months' duration. There had been no loss of weight. Examination showed a tumour the size of a goose's egg, with 2 cm. retraction of the right nipple. The lump was firm, painful on pressure, and easily movable beneath the skin and in the breast substance. No regional lymph-nodes were palpable. The tumour was easily shelled out. No clinical follow-up is recorded. Microscopy showed a highly differentiated, but definitely malignant, tumour consisting of a large ' cholesteatoma ' with several small similar cysts and an intracanalicular fibro-adenoma with squamous metaplasia of the ducts. Lahm himself considered the tumour to be metaplastic and not of cell-rest origin.

Kaufmann (1922) described, in a woman aged 45, an ' epidermoid ' cyst of the breast the size of a hen's egg, filled with yellowish, pus-like material and undergoing malignant degeneration. There was a coexistent carcinoma simplex. There is no further clinical or histological description and no illustration, but the co-existence of the carcinoma simplex makes it not unlikely that the epidermoid cyst was of metaplastic origin.

Konjetzny (1912) recorded the case of a woman, aged 34, who, when six months pregnant, noticed a movable tumour in the outer side of the right breast. It enlarged rather rapidly after a normal labour. Examination three months after parturition showed a thin woman with a mass larger than a child's head in the right breast. The tumour was fluctuant, well-defined, and movable over muscle and beneath skin. Some hard, movable axillary lymph-nodes were present.

The breast was amputated. No clinical follow-up was recorded. The tumour mass showed a cystic and solid structure very similar to that of our *Case* 1 (*see* Konjetzny's *Figs.* 2 and 3), and contained a greyish-white broth-like fluid. Microscopy showed the fluid to consist of keratinized squamous epithelial formations. The lymph-nodes were free of growth. The wall of the cyst showed both basal-celled and squamous-celled formations, often apparently malignant. In addition there were nodules of myxomatous tissue of pleomorphic structure, containing giant cells, but no epithelial elements; he considered it to be myxosarcomatous. Because of the apparent diversity of these structures, he dismissed the possibility of a metaplastic origin for the tumour and concluded that it derived from an ectodermal germ, which had retained the ability to form mesodermal structures.

It seems more plausible to explain it as a metaplastic carcinoma, the squamous cells clearly deriving from the basal cells as in normal epidermis. As for the myxomatous formations, œdematous, myxomatous-looking structure is characteristic of the interlobular tissue of the breast (Nicholson, 1924) and Konjetzny's illustration does not convincingly disprove the possibility that the ' myxosarcoma ' he describes is merely hyperplastic mammary connective tissue. This point leads on to Lecène's (1906) case :—

A nullipara, aged 54, with no significant past history, complained of a painless swelling, the size of an egg, in the right breast. It had been noticed first two months previously, with more rapid growth during the past eight days. Examination showed a softish tumour covered by reddened, violaceous skin. The tumour was not adherent either to the skin or to deeper structures. The nipple was normal. Some hard axillary lymph-nodes were present. A clinical diagnosis of adenosarcoma was made. The breast was removed and the axilla cleared. The patient recovered satisfactorily but was not followed up. Microscopically the tumour contained islands of squamous epithelium in a ' sarcomatous ' stroma. The lymph-nodes contained no growth. Lecène was convinced of its mixed and congenital (teratoid) origin. He goes on to say that the prognosis is probably good and that, if such tumours become malignant, malignancy develops in the epithelial component. This statement makes one loath to accept unquestioningly his description of a ' sarcomatous ' stroma. The squamous component of the tumour could be as easily explained by metaplasia.

To summarize : of these 4 cases, there is evidence in the first two of a possible metaplastic origin ; in the second two, evidence is lacking, but metaplasia seems to explain their histogenesis more plausibly than the theories of embryonic displacement propounded by the authors. The cystic appearance of the tumours, as in our case, is produced by the well-known tendency to necrosis and liquefaction of squamous-celled carcinoma.

Case 2.—This shows the structure of a medullary carcinoma of the breast with widespread scattered sheets of rather atypical squamous epithelium. The manner in which the latter blends with the former with almost imperceptible transitions clearly indicates its metaplastic nature. Although most descriptions of squamous-celled metaplasia in the breast refer to the duct epithelium, glandular epithelial metaplasia was described by Grohé. It is difficult in our case to decide from which element the tumour has arisen, but the gland cells seem the more likely. This type of tumour includes Geschickter's second and third groups, the distinction between which seems rather artificial.

CONCLUSION

Whilst we do not disagree profoundly with Geschickter's classification of squamous-celled carcinoma of the breast, we should like to emphasize the

probable metaplastic origin of the majority of them, in agreement with Pasternack and Wirth (1936), rather than lay too much emphasis on an epidermoid cyst origin, with the unnecessary resurrection of the Cohnheim doctrine that this view would imply. Carcinoma arising from an epidermoid cyst should not be diagnosed unless a clear indication of such a histogenesis is seen. The degree of squamous differentiation appears to be unimportant as far as the grade of malignancy goes, as the tumours in both *Case* 1 and *Case* 2 were clinically equally malignant, although *Case* 1 shows a more extensive squamous differentiation.

SUMMARY

1. Two cases of squamous-celled carcinoma of the breast are described.

2. Their histogenesis is discussed.

3. It is felt that most of these tumours arise as the result of metaplasia of duct or glandular epithelium.

4. There did not seem to be any correlation between degree of squamous differentiation and grade of clinical malignancy.

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RETROGRADE JEJUNOGASTRIC INTUSSUSCEPTION FOLLOWING GASTRECTOMY

BY IRVINE SMITH, GENERAL INFIRMARY AT LEEDS

RETROGRADE intussusception of jejunum into stomach is a well-known complication of gastro-enterostomy, even though it is fairly uncommon. Aleman collected 70 recorded cases in 1948, but many others must have occurred; I have personal knowledge of 2 unpublished cases, one correctly diagnosed and cured (Scholefield 1948), the other found at autopsy. The condition may be acute, chronic, or recurrent with spontaneous reductions, involves usually the efferent limb, but occasionally the afferent or both limbs, and can occur after any type of anastomosis, even if an additional entero-anastomosis is present. It can occur in the early post-operative days after gastro-enterostomy or up to twenty years later. The acute case usually presents the classical symptoms and signs of intussusception, viz., severe pain, intestinal obstruction and hæmorrhage, an abdominal mass, and the early onset of shock. Radiology with opaque meals has on occasions produced beautiful pictures to confirm the diagnosis.

It is not so well known that this condition may follow gastrectomy. Such a case is therefore reported.

CASE REPORT

M. D., female, aged 43 (268537), had been troubled by a gastric ulcer for three years. In March, 1953, this perforated. Her late admission to hospital delayed suture for 32 hours by which time she had purulent peritonitis with loculating abscesses. Nevertheless constitutional disturbance was not severe and she made a surprisingly quick recovery. In May, 1953, her pain and ulcer crater persisting, she was re-admitted under the care of Mr. George Armitage to the General Infirmary at Leeds and a hemi-gastrectomy was performed (I. S.), making a pre-colic afferent limb to greater curve anastomosis without any valve.

Her convalescence was rapid and straightforward and she remained well for eight months. Then on Feb. 2, 1954, she suddenly complained of severe colicky epigastric pain and began to vomit. The pain grew worse, radiating to the left side of her back and remaining more constant. Fresh blood soon appeared in the vomit. She looked haggard, tired, and undernourished. T. 98°, P. 68, R. 24, B.P. 120/80. She was in great pain but not shocked. Tongue a little furred. There was marked tenderness and muscle guarding in the left hypochondrium. Blood and bile were aspirated copiously from the stomach. Next morning she felt better and the pulse chart (*Fig.* 826) looked encouraging. Muscle guarding had diminished and a tender firm mass 3 in. × 3 in. which moved with respiration, could be felt in the left hypochondrium. Blood still came from the Ryle's tube, but there was no vomiting. A diagnosis of retrograde jejunogastric intussusception was considered, but set aside as this condition was not thought to occur after gastrectomy. Observation was continued for four days, during which time the patient felt better, the pulse chart remained satisfactory, no shock was evident, and gastric aspirations changed to clear bile except for two brief small hæmorrhages. Suitable fluid and electrolyte replacement was given intravenously. However, the mass remained and it became obvious that the efferent loop was obstructed.

Operation was therefore undertaken (I. S.), using pentothal, tubarine, gas, oxygen, and pethidine anæsthesia by Dr. Ian Stewart. The stomach was found to be greatly dilated by the intussuscepted efferent loop (*Fig.* 827 A). The outer wall (intussuscipiens) consisted not only of stomach but also of the upper 4–5 cm. of efferent loop; this strongly suggests that the intussusception

had originated at least 20 cm. distal to the anastomosis. Reduction was not possible and the outer layer of jejunum began to tear. The whole mass, including the old anastomosis, was therefore resected, dividing in turn across afferent loop, efferent loop, and stomach

gastro-enterostomy with Braun's entero-anastomosis was constructed and she remained well for ten years. In 1921 she suddenly complained of colicky epigastric pain and vomited firstly bile, but later blood. On admission she was shocked and gravely ill. A firm mass palpable

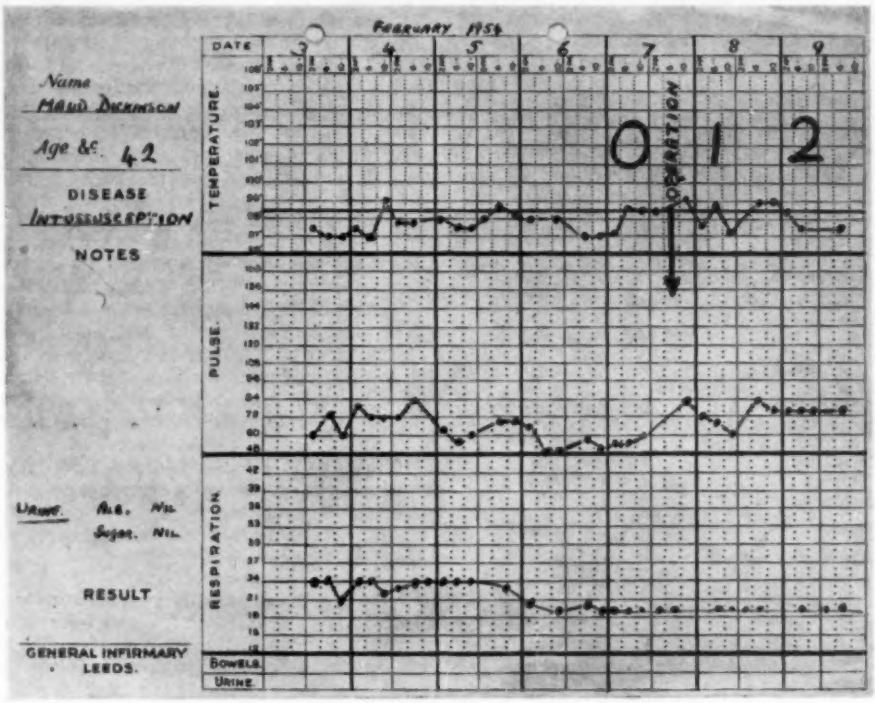

FIG. 826.—Pulse chart showing absence of constitutional disturbance before operation.

(*Fig.* 827 B). The afferent stump was too short and its stoma too disproportionate for end-to-end anastomosis with the efferent loop, so a Roux-Y reconstruction was used (*Fig.* 827 C). During this operation she received

in the left hypochondrium moved with respiration. She died on the fourth day without operation. Autopsy showed 20 in. of efferent loop intussuscepted into the stomach.

FIG. 827.—Diagram to illustrate the anatomy. A, Intussusception as found on opening the abdomen. B, Lines of transection for excising the specimen. C, Method of reconstruction.

2 pints of blood. Recovery was uneventful and she was discharged from the convalescent home on the twenty-second post-operative day. *Fig.* 828 is a photograph of the resected specimen.

I have found only 16 previous records of this condition. These have been briefly summarized below and the relevant features tabulated (*Table I*).

Case 1 (Lundberg, 1922).—In 1911 a 37-year-old woman underwent resection of the pyloric end of the stomach for alleged carcinoma. An anterior Billroth II

Case 2 (Perman, 1935).—A female, aged 31, underwent Billroth II gastrectomy for chronic duodenal ulcer. After three months there was still much vomiting. A barium meal showed retrograde intussusception into the stomach, but this was found to have reduced itself when the abdomen was opened; the patient made a good recovery.

Case 3 (McNamara, 1944).—A tabetic man, aged 45, had a posterior gastro-enterostomy for chronic duodenal ulcer in 1938 and a gastrectomy for bleeding anastomotic ulcer in 1943. At home three weeks after operation he

complained of pain and vomiting, but was not re-admitted until two weeks later. He was then moribund and soon died. Autopsy showed an enormous stomach remnant with 50 cm. of gangrenous efferent loop intussuscepted into it.

Case 4 (Aleman, 1948).—In 1927 a 27-year-old man had a Billroth II gastrectomy for chronic duodenal ulcer; a posterior gastro-enterostomy was made and he was well

FIG. 828.—Coloured photograph of the resected specimen (× ½), showing the large amount of jejunum in the stomach and the line of original anastomosis outlined by indicator stitches.

for thirteen years. In 1940, after feasting on crayfish and wine, he felt sick and then complained of severe epigastric colic, vomiting food and later blood. His serum-amylase was high and with conservative treatment he was better in three days. In 1946, this time with no known cause, the same symptoms recurred and persisted. There was tenderness but no mass in the left hypochondrium. The serum-amylase was normal and a barium meal showed intragastric intussusception. Early operation reduced 50 cm. of efferent loop from the stomach and the patient recovered well.

Case 5 (Grimes, 1949).—In 1945 a 55-year-old man had a Polya-type sub-total gastrectomy for chronic (18 years) duodenal ulcer. After three years' good health he had spinal anæsthesia for a transurethral prostatectomy and began to vomit. Epigastric colic, hæmatemesis, and shock soon followed. No mass was palpable; operation was not performed and he died twelve days later. Autopsy showed 34 cm. of gangrenous efferent loop intussuscepted into the stomach.

Case 6 (Puech Leão, 1949).—On April 15, 1945, a 33-year-old man with a duodenal ulcer underwent partial gastrectomy with retrocolic afferent loop to lesser curve anastomosis. He remained well for three years. On April 16, 1948, without known cause, he had sudden severe epigastric colic; later he vomited food and then blood. He did not look severely ill, but had epigastric tenderness. Next day a mass the size of an orange was felt in the left hypochondrium and barium meal showed intragastric intussusception. Early operation showed: (1) retrograde intussusception of 40 cm. of efferent jejunal loop into (2) a greatly dilated stomach, and (3) lack of attachment of anterior wall of stomach to mesocolon, thus leaving a 20-cm. hole in the mesocolon through which almost all the small bowel had herniated. Both the herniated and intussuscepted bowel were reduced easily, the hole was closed, and recovery was satisfactory.

Case 7 (de Toeuf, 1949).—In September, 1944, a man aged 38 underwent gastrectomy for pyloric ulcer. He remained well until October 31, 1948 when he suffered sudden and severe epigastric pain, and soon vomited food and blood. During 24-hours' observation two further hæmatemeses occurred and the blood-pressure fell. Operation showed the stomach greatly distended by irreducible retrograde intussusception of the efferent loop. Gastrotomy confirmed necrosis of the intussusception, which was then resected: 24 hours after initial recovery the patient died.

Case 8 (Vink, 1950).—On September 30, 1948, a man aged 55 with a chronic (18 years) duodenal ulcer underwent gastrectomy with retrocolic short afferent limb to lesser curve anastomosis without valve formation. A little vomiting followed operation but so much bile returned through the gastric tube during the next ten days that obstruction of the efferent loop was diagnosed and the abdomen re-opened on October 11, 1948: 8 cm. of efferent loop had intussuscepted into the stomach, but was easily reduced, and the patient recovered quickly.

Case 9 (Ulrichs, 1951).—This author successfully operated on 2 cases of retrograde jejunogastric intussusception and states that 1 patient had previously undergone gastrectomy. No further details are available.

Case 10 (Arduino, 1952).—In 1944 a man aged 34 with a chronic peptic ulcer underwent partial gastrectomy with retrocolic afferent loop to lesser curve anastomosis. He remained well for eight years. In 1952 he suddenly had severe epigastric pain, soon followed by vomiting of food and later blood. He was gravely ill. Operation showed: (1) gangrenous irreducible intussusception of efferent loop into stomach; (2) 180° volvulus of the stomach (greater curve coming anteriorly and then to the right) with gangrene of the distal segment of stomach. The gangrenous portions were excised, the jejunum joined end to end to jejunum, and a Polya afferent loop to lesser curve gastrojejunostomy constructed. Recovery was satisfactory.

Case 11 (Hublin, 1951).—Fifteen years after a Polya-type gastrectomy with entero-anastomosis for chronic duodenal ulcer, this man, aged 50, suddenly complained of epigastric colic and vomited mucus but no blood. He looked ill and shocked, the upper abdomen was distended, and a large soft sausage-shaped tumour was palpable emerging from under the left costal margin. At operation 80 cm. of invaginated efferent limb was easily reduced. Recovery was good.

Case 12 (Hublin, 1951).—Three years after a Polya-type gastrectomy with entero-anastomosis for chronic duodenal ulcer, this man, aged 28, suddenly complained of severe epigastric colic and vomited blood. When seen twenty-four hours later he was pale, shocked, and dehydrated. The upper abdomen was distended, and a tender, sausage-shaped tumour "as thick as an arm" was palpable, emerging from under the left costal margin. Intussusception was diagnosed clinically, but resuscitation delayed operation still further; 30 cm. of efferent loop had invaginated via the entero-anastomosis and adjacent afferent loop up into the stomach. Reduction revealed gangrenous efferent limb which was successfully resected, and the adjacent limbs were sutured together to prevent recurrence. Six months later, vicious circling of food and barium around efferent limb–entero-anastomosis–afferent limb–stomach necessitated conversion to Roux-Y type anastomosis, and there has been no further trouble since then.

Case 13 (Palmer, 1954).—This man, aged 48, underwent gastrectomy (? type) for a chronic gastric ulcer. Thirteen months later vagotomy was performed for jejunal ulcer, three weeks later colic and vomiting occurred, and intussusception was diagnosed by radiology but reduced itself. This was repeated six times in the next twelve months, but has not recurred since the patient started regular consumption of urecholine.

Case 16 (Welbourne, 1955).—A man, aged 42, had severe epigastric and left hypochondrial pain fourteen months after a five-sixths Polya-Balfour-type gastrectomy. was palpable. Ileus was diagnosed. At operation 70 cm. of intussuscepted efferent limb was easily reduced, the upper 15 cm. of jejunum was found still as extragastric intussuscipiens. Recovery was quick.

Table I.—RECORDED CASES

AUTHOR	DATE	AGE	SEX	TYPE OF PREVIOUS GASTRECTOMY	INTERVAL SINCE GASTRECTOMY	PALPABLE MASS	X-RAY CONFIRMATION	OPERATIVE TREATMENT	DELAY BEFORE OPERATION	REDUCTION	RESECTION	RESULT
Lundberg	1922	48	F.	Billroth II. Anterior gastro-enterostomy. Braun's entero-anastomosis	10 yr.	+	−					Died
Perman	1935	31	F.	Billroth II	8 wk.	−	+	+		Spontaneous		Recovered
McNamara	1944	50	M.	Polya: for bleeding anastomotic ulcer	3 wk.	−	−					Died
Aleman	1948	46	M.	Billroth II. Posterior gastro-enterostomy	19 yr.	−	+	+	<24 hr.	+		Recovered
Grimes	1949	58	M.	Polya	3 yr.	−	−					Died
Puech Leão	1949	37	M.	Polya: Retrocolic afferent limb to lesser curve	3 yr.	+	+	+	2 hr.	+		Recovered
deToeuf	1949	42	M.	?	4 yr.	−	−	+	30 hr.	Impossible	+	Died
Vink	1950	55	M.	Polya: Retrocolic afferent limb to lesser curve	11 d.	−	−	+	> 7 d.	+		Recovered
Ulrichs	1951	?	?	?	?	?	?	+	<24 hr.	+		Recovered
Hublin	1951	50	M.	Polya type plus entero-anastomosis	15 yr.	+	—	+	<12 hr.	+		Recovered
Hublin	1951	33	M.	Polya type plus entero-anastomosis	3 yr.	+	—	+	36 hr.	+	+	Recovered
Arduino	1952	42	M.	Polya: Retrocolic afferent limb to lesser curve	8 yr.	?	−	+	<24 hr.	Impossible	+	Recovered
Palmer	1954	43	M.	Polya-Balfour with vagotomy	3 wk.	—	+			Spontaneous		Recovered, Recurred six times
Palmer	1954	33	M.	?	5 wk.	?	+			Spontaneous		Recovered
Lund and Sauderud	1954	33	M.	Polya-Moynihan	10 yr.	—	—	+	30 hr.	+		Recovered
Welbourne	1955	42	M.	Polya-Balfour	14 mth.	—	+	+	12 hr.	+		Died
Smith	1955	43	F.	Polya precolic afferent limb to greater curve	8 mth.	+	—	+	5 d.	Impossible	+	Recovered

Case 14 (Palmer, 1954).—Five weeks after gastrectomy (? type) for chronic duodenal ulcer, this man, aged 32, suddenly complained of severe epigastric colic and vomiting. There was epigastric tenderness, but no mass. Radiology confirmed the diagnosis, but showed satisfactory emptying of the stomach. Spontaneous reduction occurred within twenty-four hours and was also confirmed radiologically.

Case 15 (Lund and Sauderud, 1954).—Ten years after gastrectomy with a long (30 cm.) afferent limb to lesser curve retrocolic anastomosis, this man, aged 33, suffered post prandial nausea, diarrhœa, and vomiting of food, bile and then blood. Severe epigastric colic followed in twenty-four hours and radiated to the back. No mass There was no vomiting or palpable mass. Diagnosis was by gastroscopy, and radiology showed in addition only partial delay of gastric emptying. At operation reduction was easy; no other abnormality was found apart from the usual degree of jejunal dilatation, and the anastomosis was converted to a Billroth I type. Unexplained nephrosis and liver necrosis proved fatal on the fourth day.

Other case records which have not been consulted have been published by Almeida and Lombardi (1948); Gutman (1950); Moutier, Cornet, and Sukan (1952); Giraud and Anjou (1953); Hammesfahr (1953); and Kalfelz (1954).

Fatal retrograde jejunoduodenal intussusception three years after total gastrectomy with Roux-Y anastomosis has been recorded by Davey (1954). The distal jejunal limb had entered and ascended the blind limb almost to the duodenal stump, causing gross obstructive distension of the œsophago-jejunal limb.

DISCUSSION

It is obviously important to know that this complication may follow gastrectomy as well as gastro-enterostomy. The clinical picture is much the same after either operation. The interval between gastrectomy and intussusception was less than two months in a third of the patients, although it has also been as long as 10, 15, and even 19 years; so the condition should be considered amongst other causes of post-operative vomiting.

The intussusception was palpable in only 5 out of the 17 gastrectomized patients described—less frequently, that is, than intussusception following gastro-enterostomy, probably because the gastrectomy stoma is higher and the mass thus more concealed by costal margin. So one should not be put off the diagnosis by failure to feel a mass; nor is the diagnosis excluded by finding normal gastric emptying, which occurs usually with afferent limb and occasionally even with efferent limb involvement.

Sudden epigastric colic, vomiting of food and then blood, and the early onset of shock, constitute a classical triad, at once suggesting the diagnosis; gastroscopy and barium-meal examination immediately provided confirmation on the six occasions they were used, and should therefore be routine investigations where the diagnosis is a possibility.

It has been suggested (Palmer, 1954) that spontaneous reduction is commoner when the afferent limb is involved. But it is not easy without operation to be certain which limb is involved, spontaneous reduction is the exception rather than the rule, early operative reduction is usually easy, and delay increases the mortality, so operation should not be postponed longer than necessary once the diagnosis has been made. Of 12 patients undergoing operation, only 2 died—1 following an attempted transgastric resection and 1 from unexplained nephrosis and liver necrosis. In contrast there were 3 deaths amongst 5 patients not receiving operation. It is worth noting that an irreducible or gangrenous intussusception is more easily resected after gastrectomy than after gastro-enterostomy, and this was performed successfully on three occasions.

To produce retrograde intussusception one would expect peristalsis to be abnormal both in degree and direction. Yet only 2 patients had a known cause of nausea and vomiting at the onset, though possibly others ignored or forgot some trivial cause. As so many gastrectomized patients vomit at some time or other, and as this intussusception is so rare, there are probably other causes. For instance, the artificial stoma allows local intragastric prolapse of jejunal mucosa; this has been demonstrated by radiology and could probably initiate intussusception. Another factor may be jejunal hyperperistalsis, which some authors have claimed to demonstrate in gastrectomized subjects by kymographic techniques; furthermore, the intussusception must have commenced low in the jejunum in those cases in which jejunum was found still forming part of the outer wall. Local tumours, however, have never been demonstrated as a cause of this type of intussusception.

The complication has been described after practically every type of gastrectomy anastomosis, except gastroduodenal (Billroth I); e.g., anterior or posterior, Billroth II, Polya-type, with pre-colic or post-colic loops connecting the afferent limb to either gastric curvature; it has even traversed a Braun's entero-anastomosis and also ascended the blind limb of a Roux-Y anastomosis. The freedom of gastroduodenal reconstructions from this as well as other types of late organic obstruction described by Stammers (1954) is another important factor favouring Billroth I, as opposed to Polya-type gastrectomies.

SUMMARY

1. An irreducible retrograde jejunogastric intussusception following gastrectomy was successfully resected and is described.

2. Sixteen other case records have been collected from the literature and reviewed.

3. Diagnosis is discussed, emphasizing the value of radiological investigation.

4. Early operation is recommended as the safest treatment.

I should like to thank Mr. George Armitage for allowing me to treat this patient under his care and to publish details; also Mr. Pegg, of the Department of Photography, Leeds University, for his coloured illustration.

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EXPERIMENTAL SURGERY

NUCLEAR CRYSTALS IN SLOWLY-FROZEN TISSUES AT VERY LOW TEMPERATURES

COMPARISON OF NORMAL AND ASCITES TUMOUR CELLS

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It has been realized for some time that most normal tissues are severely damaged or killed when they are cooled to very low temperatures. Pate (1954) has pointed out that there is a definite need for grafts of preserved tissues in modern surgery, and that an ideal preserved graft is one which, after storage and implantation, immediately and permanently fulfils all the normal physiological functions of the replaced tissue. In the light of present knowledge of the lethal effects of cold, these requirements cannot be met, but renewed interest in the subject has arisen from the successful use of substances such as glycerol and ethylene glycol to protect cells at low temperatures.

One of the most important problems concerns the direct effect of very low temperatures on the living cell and its immediate environment. Very little work has been carried out on the appearances of whole tissues at low temperatures, and in a previous article two methods were mentioned for making permanent preparations to demonstrate the changes in tissues which had been slowly frozen to −79° C. (Heard, 1955). There was great distortion of the tissue by large numbers of crystals outside the nuclei, but probably the more significant finding was that ice-crystal spaces developed *inside* a high proportion of nuclei and often distended them until they could be identified only by a thin chromatin margin around the periphery of the crystals.

This nuclear crystallization has been investigated further and the present article reports work showing that nuclear crystals are not demonstrable in a large proportion of Sarcoma 37 ascites tumour cells which are able to resist slow freezing. The possible significance of these findings will be discussed with reference to recent writings on this subject.

METHODS

Slow freezing was performed, as before, by placing the tissue or exudate on copper angles and sealing these in dry test-tubes in an alcohol bath, the temperature of which was lowered by 1° C./2 minutes by adding fine powdered solid carbon dioxide. A little alcohol in the carbon dioxide prevented it from caking. At −79° C. cold absolute alcohol at that temperature was added to the specimens and the angles were detached from the frozen tissue samples by light taps with a spatula.

It was stated previously that the quality of fixation was improved by stirring the cold alcohol, but the tissue became covered by ice from the neck of the test-tube. This has been overcome by using buckets (2·0 × 1·0 × 0·5 cm.) of copper gauze (40 squares to 1 in.). The detached tissue was transferred to the buckets, which were bent to a right-angle at the centre to prevent escape and to present flat gauze surfaces to the directions of movement. Each bucket was connected by thin wire to a horizontal rod, and twelve or more could be agitated at the same time by raising and lowering the horizontal rod mechanically (through about 2·5 cm. at 25 cycles per minute). The tissue was thus exposed on all sides to currents of absolute alcohol at −79° C., and the procedure was maintained night and day for about 200 hours during the next two weeks.

Obviously such a method is not necessary for the plain demonstration of ice-crystal spaces in tissues, but for the study of nuclear crystals it is necessary to take every precaution to avoid under-fixation since the absence of nuclear crystals seems to be important. Unfixed nuclei recover considerably on thawing and give little or no histological impression of the changes to which they have been subjected (*see Figs.* 522 and 525 in the previous article). The pieces of tissue were kept small.

At the end of the fixation period the refrigerant was removed from around the tubes and thawing took about 30 minutes at room temperature. Several changes of absolute alcohol were given for 2 hours to remove water released by the ice-crystals on thawing and the tissue was cleared in cedarwood oil and blocked in paraffin wax. A better view of the nuclei was obtained by staining with haematoxylin alone than by combining this stain with eosin. The cytoplasm of the frozen ascites tumour cells appeared dense and sections 3–4μ thick were necessary to demonstrate nuclear detail.

The ascites tumour was a Sarcoma 37 kindly supplied by Dr. James Craigie. Ascitic exudate of advanced tumours in mice could be stored undiluted in sterile test-tubes after slow freezing. In this form the tumour remained alive in storage at −79° C. and could be thawed rapidly by transferring the test-tube to water at 37° C. It never failed to produce a tumour when given 0·05 ml. intraperitoneally to mice. Dilution was avoided to provide parallel histological observations where such a procedure would have encouraged disintegration during freeze-fixation. The exudate gave rise to tumour nodules when injected (0·05–0·1 ml.) subcutaneously into the abdominal wall of mice, and these tumours also were slowly frozen and examined by cold alcohol fixation. Many were transplanted subcutaneously for survival studies.

RESULTS

There have been only occasional reports of the ability to demonstrate survival of normal tissues after slow freezing in the absence of pre-treatment with survival-promoting substances. Nuclear ice-crystal formation is a prominent feature of normal rat tissues after freezing (as reported in the previous article), and the same applies to mouse tissues now illustrated in *Figs.* 829, 830.

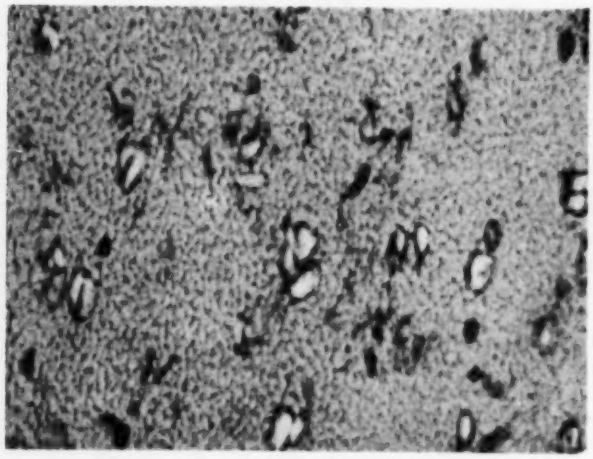

FIG. 829. Cerebral cortex of mouse fixed at −79° C. after slow freezing. There are several ice-crystal spaces in the nucleus of each nerve-cell and small spaces can be seen among nerve-fibres. (× 600.)

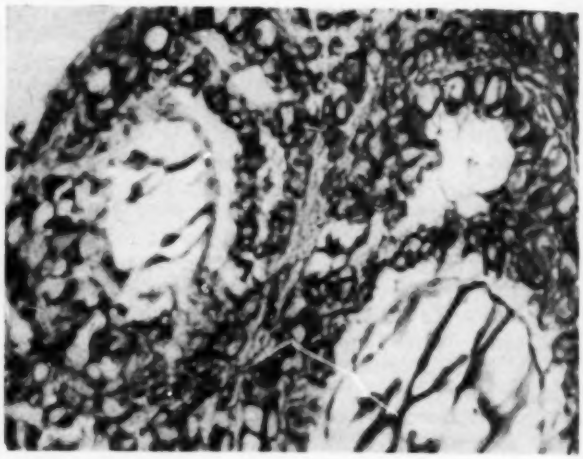

FIG. 830. - Ovary of mouse fixed at −79° C. after slow freezing, showing ice-crystal spaces in and between the nuclei of follicular and other cells. (× 600.)

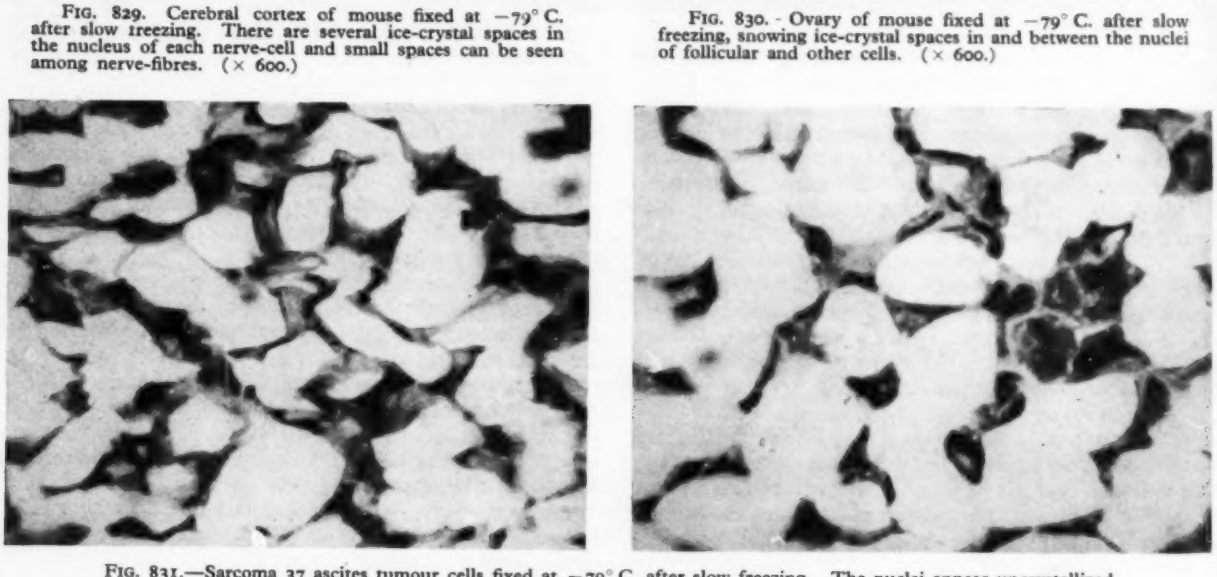

FIG. 831.—Sarcoma 37 ascites tumour cells fixed at −79° C. after slow freezing. The nuclei appear uncrystallized, but the cells are distorted by extracellular ice-crystals. (× 860.)

The procedure has been applied to cells known to survive slow freezing. Craigie (1952) has described how mouse tumours, such as Sarcoma 37, grown as ascites tumours, readily assume a paramorphic state in which they are able to survive slow freezing and storage at −79° C. for several years. This tumour was investigated by both freeze-drying and alcohol fixation methods to determine the state of such cells at −79° C.

The appearances of this ascites tumour at −79° C. are seen in *Fig.* 831. The tumour cells are distorted by large intercellular crystals, but the majority of nuclei are not crystallized. Cytoplasm and nuclei appear shrunken and the few cellular spaces are cytoplasmic vacuoles. Freeze-drying, again after slow freezing, shows the same appearance. This finding was associated with the survival and growth of parallel samples of the tumour on transplantation.

When Sarcoma 37 is propagated as a solid tumour subcutaneously, the active cells are in a state in which they cannot readily assume the resistant paramorphic state and do not survive freezing. Samples of these were subjected to slow freezing and cold alcohol fixation, and in *Fig.* 832 the single or multiple ice-crystal spaces are illustrated. This appearance closely resembles that of frozen normal tissues and contrasts sharply with the paramorphic cells in the previous figures. The nuclear crystallization agrees with the inability of the majority of cells to survive freezing. Near necrotic areas the nuclei are not crystallized and some preliminary trials with parallel samples after transplantation show some survival. This is in agreement with Craigie's observations with phase microscopy that in solid tumour cells in the paramorphic state are found bordering such necrotic areas.

In normal rat and human blood quite a number of polymorphonuclear leucocytes can be seen to escape nuclear crystallization, and this finding is mentioned in the following discussion.

DISCUSSION

The basic finding now reported is that nuclear ice-crystals cannot be demonstrated by these methods in the majority of slowly-frozen ascites tumour cells of Sarcoma 37 at −79° C. These cells are capable of changing into the paramorphic state (Craigie, 1954), in which they survive very low temperatures. In contrast to this, nuclear crystals can be demonstrated with ease in a large proportion of normal rat (Heard, 1955) and mouse tissues at −79° C., and in the same tumour growing subcutaneously; normal tissues rarely survive slow freezing and Craigie has pointed out that in the subcutaneous tumour the cells are in the β state and do not survive freezing.

Although the high resistance of ascites tumour cells to freezing is well known, histological studies of present type have not been carried out to date. For this reason it is necessary to discuss whether the findings can be correlated with current opinions of the manner of cell death at low temperatures. There is much to suggest that crystallization within the cell marks the point of death, but some evidence has accumulated to show that in many cells death occurs before intracellular crystallization takes place (Smith, 1954).

The view taken from the present findings is as follows: The presence of nuclear ice-crystals in cells under these conditions means, in all probability, that they are dead. The absence of nuclear crystals indicates that the cells have given up much of their water during freezing and the rising concentration of intracellular solutes may or may not have been sufficient to kill them.

The first point to consider is whether work to date has shown that intracellular crystals denote cell death. Using the sartorius muscle of the frog, Chambers and Hale (1932) showed that a muscle-fibre coated with ice-crystals at just below 0° C. remained capable of contracting. As long as the fibre itself was unfrozen recovery was apparent. When the cytoplasm crystallized as a result of exposure to temperatures in the region of −15° C., or after the cell membrane has been pierced by an ice-tipped micro-pipette, no contraction could be induced after thawing. These authors stated that fibres in which internal freezing was complete were always found to be dead on thawing. Whilst the plasma membrane remained intact, the interior of a cell could be sub-cooled below the temperature of its freezing point. It was concluded that the plasma membrane of the living cell acts as a barrier against internal freezing and that if that breaks down internal freezing kills and the cell plasmolyses on thawing.

More recently techniques have been developed for observing the behaviour of cells in suspension at very low temperatures, and it has been possible to see intracellular crystallization taking place in a number of cell types. Smith, Polge, and Smiles (1951) studied the appearances of amœbæ in rain-water by phase-contrast microscopy and showed that at about −8° C. they suddenly darkened and small crystals could be seen within margins of cells and in contractile vacuoles. On thawing, the cell membrane ruptured in at least one place, so that cytoplasmic granules drifted out into the medium. Smith and Smiles (1953) showed that ice crystals also appeared in corneal epithelial cells at between −5° and −10° C. when they 'blacked out'. A similar change was seen in preparations of guinea-pig testis, with cellular disintegration on thawing.

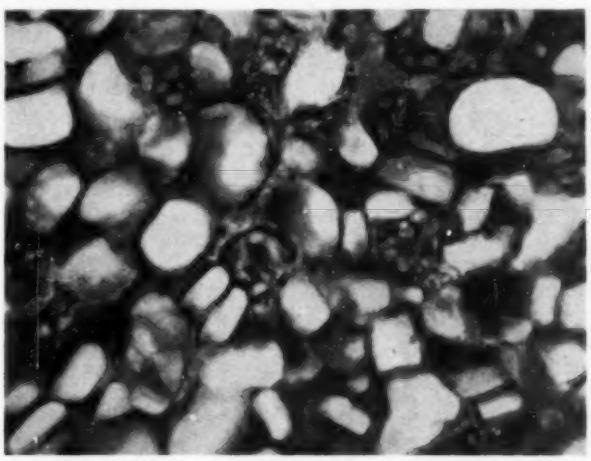

FIG. 832.—Sarcoma 37 grown subcutaneously and fixed at −79° C. after slow freezing. The nuclei are distorted by ice-crystal spaces. (× 860.)

Lovelock, quoted by Smith (1954), found that the brine shrimp, *Artemia salina*, failed to recover once intracellular crystallization had occurred. It also appears to kill plants (Siminovitch and Scarth, 1938; Rogers and Medlibowska, 1953). The subject has been reviewed recently by Smith (1954), and while it seems fairly certain that crystallized cells are dead there is accumulated evidence to show that in many cells death occurs before intracellular crystallization has taken place.

Luyet (1951) and his co-workers have endeavoured to avoid intracellular crystals by freezing tissue very rapidly in an effort to vitrify the protoplasm. Some considerable success has been achieved by this procedure, but other observers have shown that the survival of many tissues has been more satisfactory after slow freezing, for example, tumour tissue (Craigie, 1954). Rapid freezing may not achieve protoplasmic vitrification and survival after either slow or rapid freezing in the absence of survival-promoting substances or dehydration could be due to a small proportion of cells which resist crystallization under either condition. Slow freezing would seem likely to give such cells a better chance to adapt themselves to the changes.

Further evidence that intracellular crystal formation denotes severe damage or cell death is afforded by direct observations of glycerol-treated cells at reduced temperatures. Glycerol (Polge, Smith, and Parkes, 1949) has been used to great advantage in protecting a variety of cells against low temperatures, and there is evidence that many corneal and testicular cells so treated do not show intracellular crystallization at −80° C. where untreated samples crystallized internally between 0° and −10° C. (Smith and Smiles,

1953); on thawing the treated samples were morphologically unaltered. The androgenic tissue of the testis of the young rat can be preserved in viable condition for long periods by freezing in media containing glycerol (Parkes and Smith, 1954, a). The same applies to rat adrenal cortex (Parkes and Smith, 1954, b) and to rat ovarian tissue (Parkes and Smith, 1952). The absence of intracellular crystals is thus probably associated with cell survival.

If there is such strong evidence that intracellular crystallization marks a dying point in the reaction of a cell to falling temperatures, and if glycerol may prevent its occurrence, it might be suggested that the absence of nuclear crystals—as demonstrated here in the ascites tumour and in a small proportion of normal tissue cells—would always mean survival. So far, however, no reference has been made to the importance of increasing electrolyte concentrations, as stressed by Lovelock (1954). At −5° C. normal physiological suspending media would have concentrated nearly ten times. Very few cells are capable of withstanding exposure to concentrated salt solutions; consequently Lovelock believes that most are irreversibly damaged long before their suspending medium has concentrated to saturation. The red blood cells are the only tissue in which this feature of freezing has been carefully examined, but the way in which ascites tumour cells resist freezing and crystallization suggests that they may be able to withstand high concentrations. The shrinkage, evident in *Fig.* 831, is in agreement with such a thesis. Taking these views together, it would appear that during slow freezing concentrated electrolytes damage a cell, or kill it, while there is still a large amount of water present. This gives rise to the nuclear ice-crystal spaces, but if the cell survives, or if it dies at a very high concentration of surrounding electrolytes, or if it contained very little water before freezing, it will not show crystalline change.

Meryman (1953, a, b) examined the rat liver by a method of freeze-drying followed by alcohol fixation, using faster rates of freezing than the author, and demonstrated principally extracellular ice-crystals at such rates. He stated that freezing is characterized primarily by extensive plasmolysis of the cell, undoubtedly by rupture of intercellular bridges where they exist and possibly minute ruptures of the cell membrane. Such factors may give some assistance in explaining why the Sarcoma 37 crystallizes as a solid tumour but hardly at all as an ascites tumour. Freely suspended ascites cells would be able to change the relationships of their boundaries to the surrounding crystals. On the other hand, solid tumour cells attached to one another and to mesenchymal tissue, could be torn when intercellular crystals pushed them to one side. The effect would be similar to the membrane puncture of Chambers and Hale (1932), *see above,* and membrane rupture may be an accessory mechanism to the damaging effects of high concentrations of extracellular solutes. Obviously it is too early to speculate further on this point; more investigations are needed before the mechanism of cell survival or death at low temperatures is better understood.

The quantitative aspects of this work should be mentioned. The differences between normal tissues, subcutaneous Sarcoma 37 and the resistant ascites tumour cells are not absolutely sharp. In the normal tissues so far examined, a small proportion of uncrystallized nuclei can often be found. In the ascites tumour cell preparations the reverse applies—there are crystals in only a small proportion of the nuclei.

Craigie (1951, a) has shown that the ascites tumour cells, under certain environmental changes such as oxygen depletion or transfer to dextrose solution, change to the paramorphic state. The adverse conditions of late tumours used in the present study, together with the slow rate of drop in temperature should induce the change to this state of a large proportion of the cells previously in the α state. The minority which show nuclear crystals at −79° C. are probably those which fail to adopt the paramorphic state. These may be the cells which undergo degenerative changes after rapid thawing (Craigie, 1954).

In the preparations of slowly-frozen subcutaneous tumours a large proportion of the cells did contain nuclear crystals, but some did not. The majority would be in the β phase of Craigie which, he states, do not readily assume the paramorphic inactive state *in vitro* and do not survive freezing. The minority which do not crystallize probably correspond to the small number of cells which Craigie (1951, b) has seen "bordering necrotic foci and scattered among other cells, necrotic debris and associated fluid", and which may possibly be resistant cells.

Hadfield (1954) has discussed the part such resistant cells could play in the phenomenon of temporary growth suppression in tumour pathology. In noting, also, that a number of normal tissues survive freezing, for example, the thyroid and parathyroid (Blumenthal and Walsh, 1950), he suggests that the ability to survive in a frozen environment without any loss of former reproductive power is a property which the cells of some malignant tumours share with certain normal cells. The present findings, and those previously reported, support this suggestion. The minority of cells without nuclear crystals in normal tissues may be resistant cells and then yet another apparently distinctive feature of malignant cells would be applicable to normal cells. The present method should be of assistance in attacking this problem.

The significance of the differences in shape and size of nuclear crystals cannot be assessed at present. They vary, by this uniform rate of freezing, according to the type of cell and to the species of animal. The initial water content, together with the degree of dehydration at the point of crystallization, are probably the principal factors concerned.

To conclude, the present technique demonstrates a feature of freezing that has not been investigated previously—namely, the occurrence of large nuclear ice-crystals in the majority of slowly frozen normal tissue cells at −79° C. Taking into account the recent work on the subject, it would appear that the mechanism of this phenomenon is as follows: The suspending medium of the cells becomes frozen first, leading to increasing concentration of the electrolytes. If a cell succumbs to this altered medium early in the freezing process it may still contain enough water to freeze and produce nuclear crystals. If it can resist the increasing concentration

of the medium, it loses water and shows no evidence of crystallization in the preparations at −79° C. If it dies early, but the nucleus originally contained very little water, the same appearance can be expected. Uncrystallized it may still be alive, and with ascites tumour cells this is certainly the case, but in frozen blood some of the neutrophil leucocytes react in a similar manner and do not resume amœboid movement after rapid thawing. This means that only survival studies can settle whether lack of crystals indicates life or death of the cell.

SUMMARY

Normal rat and mouse tissues have been slowly frozen and fixed at −79° C. The majority of the nuclei contain ice-crystals and this in all probability indicates death of these cells.

The majority of nuclei of Sarcoma 37 ascites tumour cells do not show nuclear crystals and survive slow freezing. This tumour, grown subcutaneously, shows large nuclear crystals.

It is thought that the rising concentration of surrounding electrolytes kills many normal cells before dehydrating them. Nuclear crystals form from the remaining intracellular water. Resistant tumour cells may adapt by giving up cell water and no nuclear crystals are demonstrated. While nuclear crystals probably indicate cell death, the absence of crystals may indicate cell survival in some cases.

This work was carried out with the aid of a grant from the Imperial Cancer Research Fund. I wish to thank Dr. James Craigie and Professor Geoffrey Hadfield for their advice. Thanks are due also to Mr. E. V. Willmott and to Mr. J. Mercer for the photographs.

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SHORT NOTES OF RARE OR OBSCURE CASES

A CASE OF SECONDARY MELANOMA OF THE GALL-BLADDER PRESENTING AS ACUTE CHOLECYSTITIS

BY C. Q. HENRIQUES

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WHILST secondary malignant disease of the gall-bladder is no rarity, an isolated secondary melanoma in that organ is very uncommon, and the curious manner in which this case presented makes it worthy of record.

CASE REPORT

The patient was a woman of 59 years of age who had had three small pigmented moles just above her right ankle since childhood.

She first attended the hospital in November, 1949, with the history that ten months previously she had knocked her right ankle, and shortly after this had noticed that one of the moles had started to enlarge and finally a small ulcer had developed in it.

The affected area was widely excised and skin grafted. The pathologist's report confirmed the clinical diagnosis of malignant melanoma (pigmented). At this time there were no palpably enlarged inguinal nodes and no abnormal signs on abdominal examination; she was given post-operative deep X-ray therapy to the right groin area.

She remained well until August, 1952, when she developed enlargement of the lymph-nodes in her right groin. A block dissection was performed and the sections showed extensive secondary deposits of melanoma (non-pigmented).

Following this she had no further trouble until July, 1953, when she was admitted to the hospital with the symptoms and signs of acute cholecystitis. She was treated conservatively and after the condition had settled a cholecystogram was done. This showed a solitary gall-stone in a non-functioning gall-bladder. In view of her previous medical history, the possibility that her symptoms might have been caused by secondary deposits in the liver was borne in mind, and it was decided to temporize on the question of subsequent cholecystectomy.

Apart from a mild flatulent dyspepsia and an inability to eat fried foods, she had little in the way of symptoms for ten months after this, but then she developed a further attack of what appeared to be subacute cholecystitis. This was treated at home and subsided quite rapidly.

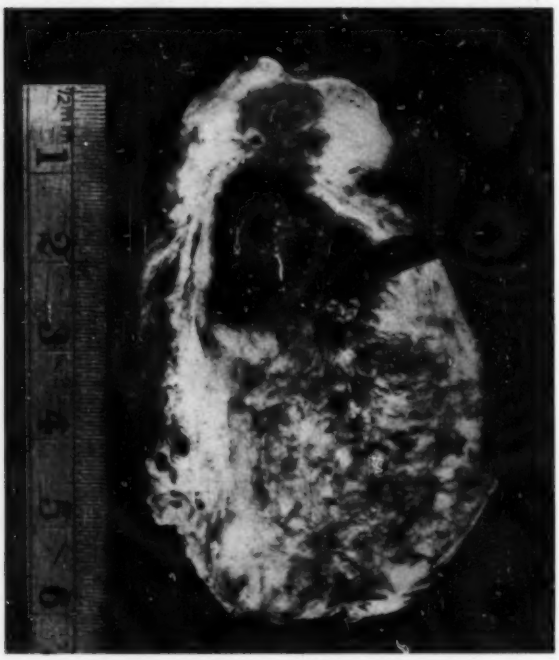

FIG. 833.—Vertical section through the gall-bladder showing the fundus replaced by tumour and a stone in the region of Hartmann's pouch.

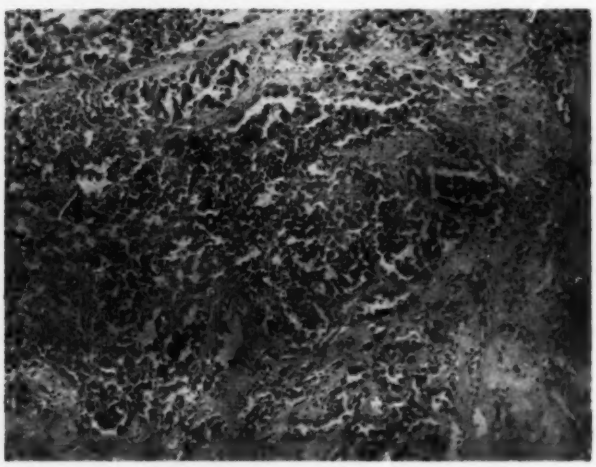

FIG. 835.—Photomicrograph to show melanin-containing tumour cells. (× 60.)

When, in June 1954, she was admitted to the hospital with a third attack of cholecystitis it was felt that immediate cholecystectomy was justified. She had developed an acute pain in the right hypochondrium twelve hours previously, and had been vomiting off and on since. On examination she was not jaundiced, her temperature was 100° F., and she had marked tenderness and guarding in the right upper quadrant of the abdomen. No intra-abdominal mass was palpable and as far as her previous operation sites were concerned there was no evidence of recurrence.

AT OPERATION.—The gall-bladder appeared to be acutely inflamed and under considerable tension, and an attempt was made to aspirate its contents. After passing a needle to some depth into the wall of the gall-bladder without tapping any fluid, it was presumed that the appearance was due to œdema of the wall of the organ, rather than to tension within it, and cholecystectomy was proceeded with.

The liver appeared healthy and contained no secondary deposits, and the gall-bladder stripped easily from its surface. Careful palpation revealed no suggestion of intra-abdominal secondary deposits in the iliac or para-aortic nodes.

The patient recovered uneventfully and has since remained well and symptom free.

FIG. 834.—Section showing the growing edge of the tumour. (× 35.)

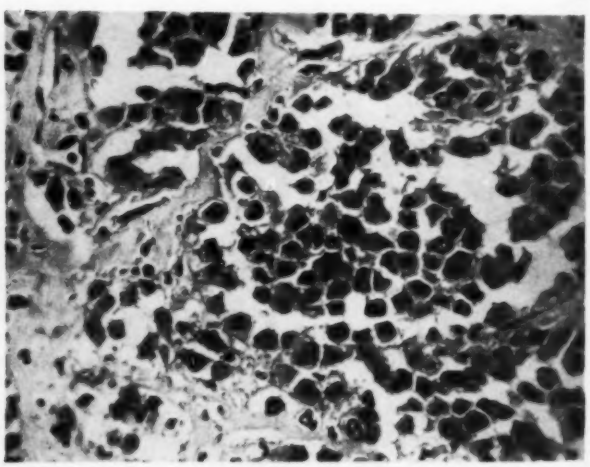

FIG. 836.—Photomicrograph to show melanin-containing tumour cells. (× 262·5.)

THE SPECIMEN.—This measured 7 cm. long by 4 cm. wide, and its peritoneal surface had many adherent fibrinous tags, and showed signs of acute inflammatory change.

On section, the fundal half was entirely replaced by a mottled yellowish-brown mass. Its surface was papilliferous and in places necrotic, and projected into the small residual lumen of the gall-bladder.

In the region of Hartmann's pouch was a rounded granular stone 1·4 cm. in diameter. A more deeply pigmented area was evident in the region of the cystic duct, and can be seen in the accompanying illustration just above the stone (*Fig.* 833).

Microscopy revealed a partly necrotic malignant melanoma invading the wall of the gall-bladder and projecting into its lumen. Numerous clumps of melanin-containing cells were found scattered throughout the tumour, as shown in *Figs.* 834-836. The tumour had almost entirely replaced the gall-bladder wall, and was responsible for the greatly increased thickness of the latter noted at operation.

DISCUSSION

This case, though in some respects a surgical curio, does illustrate one well-recognized feature of malignant disease of the gall-bladder—namely, its close association with chronic irritation. Illingworth and Dick (1945) state that carcinoma of the gall-bladder is almost invariably an end-result of chronic cholecystitis, in most cases accompanied by gall-stones. It is interesting to speculate in this instance as to whether these two factors played any part in determining the unusual site for an apparently isolated metastasis.

A search of the literature has failed to reveal any similar cases apart from that reported by Rosenthal (1931) as a primary melanoma, but which, as Willis (1948) points out, may well have been a secondary deposit from a small primary growth of skin or eye which had eluded discovery. Unless this possibility can be absolutely ruled out the primary visceral origin of a melanoma cannot, in his view, be accepted.

I am indebted to Mr. R. S. Murley for permission to publish this case, and to Dr. P. M. Peters for the pathological report.

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EPIDERMOID CARCINOMA OF THE RECTUM ARISING IN A CONGENITAL URINARY CYST

BY MURRAY T. PHEILS AND CHARLES F. ROSS

CASE REPORT

MRS. A. G., aged 79, was seen as an out-patient on June 6, 1953, complaining of rectal hæmorrhage during the previous six months. On rectal examination a hard mass was palpable in the right lateral rectal wall at finger-tip distance. The mass was relatively fixed and no definite ulceration was palpable. Bleeding obscured proctoscopy but a biopsy specimen was taken. The latter showed an anaplastic epidermoid carcinoma (*Fig.* 837), and in view of this a thorough pelvic examination was done, which excluded a growth in the cervix or vagina.

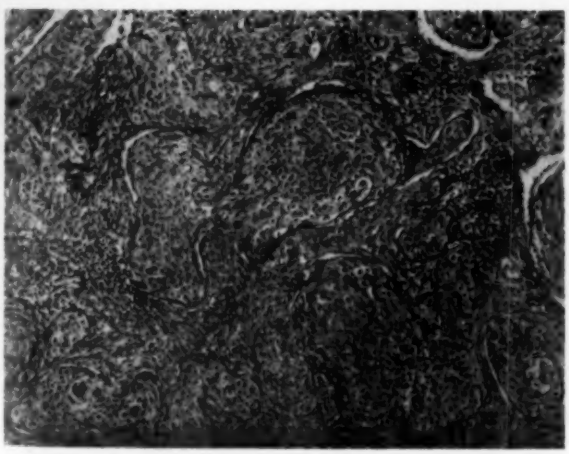

FIG. 837.—Photomicrograph of biopsy specimen. (× 80.)

The patient was admitted to hospital on June 22, and combined synchronous abdomino-perineal resection was performed on July 7. A cyst about 5 cm. in diameter was found attached to the right lateral rectal wall. The cyst burst during dissection from the peritoneal reflexion and was found to contain blood-stained fluid. There was no apparent connexion between the cyst and the uterus, ovary, ureter, or bladder. The tumour was palpable at the point of attachment of the cyst to the rectum.

The patient made a good recovery from the operation and when last seen on July 20, 1954, was in good health and free from clinical recurrence.

FIG. 838.—Photograph of inside of rectum showing a tumour in the right posterolateral wall. (× ⅔.)

PATHOLOGY.—The specimen consisted of the anus, rectum, and part of the colon, measuring 35 cm. Multiple hæmorrhoids were present and in the right posterolateral wall, projecting for 1·5 cm. into the lumen of the rectum, was a firm solid tumour 4·5 cm. diameter, its lower edge being 3·5 cm. from the anus. Its surface was granular,

superficially ulcerated, and somewhat depressed in the centre (*Fig.* 838). The rest of the mucosa appeared normal apart from a few small diverticula at the upper end of the specimen. The general appearances were more

FIG. 839.—Drawing of rectum from behind, showing the cyst and tumour, with a neoplastic lymph-node adjoining.

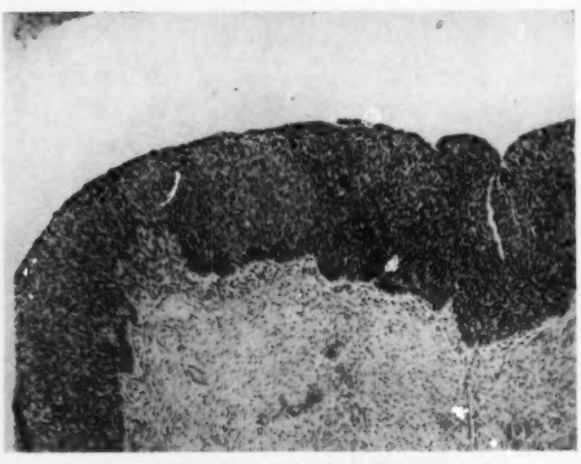

FIG. 840.—Photomicrograph of cyst lining. (× 80.)

like those of a tumour invading from the outside than a typical rectal carcinoma.

Examination of the adjoining connective tissues revealed a cyst 5 cm. diameter, situated in the right posterolateral wall, which had a corrugated lining and, in the medial wall, a projecting mass continuous with that in the rectum (*Fig.* 839). Two neoplastic lymph-nodes were attached to the outer wall of the cyst.

HISTOLOGY.—Sections of the main tumour mass show substantially similar appearances to those seen in the biopsy, viz., an anaplastic epidermoid carcinoma. There is much chronic inflammation and the mass is cut off into varying sized lobules by fibrous tissue. There are a few areas of keratinization and foci of necrosis. Mitoses are fairly frequent. The neoplastic lymph-nodes are replaced by growth which in this situation is transitional-celled. Sections of the cyst wall show it to have an inflamed layer of fibrous tissue incorporating bands of plain muscle, lined by hyperplastic, transitional, stratified epithelium (*Fig.* 840) which in places is forming villus-like projections (*Fig.* 841) similar to a bladder papilloma, and has a number of abnormal mitoses. In some places the lining has become cubical or flattened, and in parts has been lost altogether.

DISCUSSION

There seems little doubt that the tumour arose in the cyst outside the rectum. The cyst is lined by transitional epithelium and the tumour closely resembles a vesical carcinoma. It seems reasonable to suppose that this tumour is an epidermoid carcinoma arising in a congenital cyst of urinary origin.

The possibility of its arising in a diverticulum lined by metaplastic epithelium was rejected on account of the size, situation, general appearance, and presence of a complete layer of involuntary muscle in the wall. It is known that squamous metaplasia and cystic degeneration may occur in primary rectal neoplasms, but in the present case the tumour appears to arise from the cyst and not the cyst from the tumour. It appears likely that the cyst was of congenital origin and probably arose during the formation of the entodermal cloaca.

We have been unable to trace a similar case in the literature and no similar tumour has been seen at St. Mark's Hospital for Diseases of the Rectum or elsewhere by Dr. Cuthbert Dukes (personal communication).

FIG. 841.—Photomicrograph of cyst lining showing villus-like projection. (× 80.)

SUMMARY

A case of epidermoid carcinoma arising in a cyst of urinary tract origin involving the rectum is described.

Our acknowledgments are due to Dr. Cuthbert Dukes for his ready assistance and criticism; and to Mr. Gordon Cox, who performed the perineal resection. The drawing was executed by Miss B. E. Nicholson.

LIVER ABSCESS DUE TO FOREIGN-BODY MIGRATION FROM THE ALIMENTARY TRACT

A REPORT OF TWO CASES

By F. E. D. GRIFFITHS

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INJURIES to the liver are nearly always due to external trauma: war injuries, road traffic accidents, and industrial injuries, particularly those encountered in coal-mining. In these cases the usual result is effusion of blood into the peritoneal cavity (Bauer, 1921).

Abscess of the liver arising as a result of internal injury due to migration of foreign bodies from the gut is a rare condition. The ingestion of foreign bodies such as pins, coins, and animal and fish bones, is a fairly common occurrence. Occasional perforation of the intestine does take place from time to time, requiring surgical interference (Ginzburg and Beller, 1927; MacManus, 1941; Macfarlane, 1948; Wade, 1952).

The lesions described below were found at autopsy. In *Case* 1 the body came under the notice of H.M. Coroner owing to the lack of medical history and the sudden demise of the patient. In *Case* 2 the patient was a certified lunatic, and the illness, although perplexing to the medical attendants, did not on the evidence warrant a Coroner's inquiry, though the case was reported to H.M. Coroner under the Coroner's Amendment Act of 1926.

CASE REPORT

Case 1.—A man of average build, aged 45, was admitted in a moribund condition, and after two hours he died. No medical history was available.

Post-mortem examination showed a well-nourished man of middle age. The left leg had been amputated 3 in. below the knee. Examination of the abdomen showed the pylorus adherent to the under-surface of the liver between the gall-bladder and the suspensory ligament. Dissection revealed a small perforation at the pylorus. In the perforation was the head of a needle. The needle was of the type in common household use. The main part of the needle was in the liver, to a depth of 3½ cm. (total length 4 cm.). The head contained a small eye, through which about 10 cm. of black cotton thread was looped. The point of the needle led into a large irregularly shaped abscess. The abscess was confined to the lower part of the right lobe, the greatest diameter being 10 cm., and the cavity being lined by a pyogenic membrane. The abscess was black and contained foul-smelling pus. The stomach was distended and the perforation of the pyloric canal was in the upper and anterior wall. The perforation was ½ cm. in diameter and led through to the liver at an angle of 45°. The remaining portions of the liver were normal apart from cloudy swelling. The gall-bladder and portal vein were not damaged. The lungs showed hypostatic pneumonia. The other organs were normal.

Case 2.—The patient, a woman of 62, had been a certified lunatic since 1919. The case notes revealed a history of several illnesses; scabies, conjunctivitis, fracture of the right wrist, pernicious anæmia, and two attacks of diarrhœa. The first attack of diarrhœa occurred in 1932, and at the time the stool was noted to contain several foreign bodies, including a large piece of bone.

The final illness lasted fifteen days. It was ushered in by an attack of copious vomiting, with a temperature of 102°. The patient resisted examination. Diarrhœa was added to continued vomiting, and the patient was obviously in considerable pain. Bacteriological examination of the stool showed the presence of *Sh. flexner*. Conjunctivitis of the left eye was noted and a herpetiform rash on the lips and the left side of the face followed. After thirteen days the patient became semi-comatose. The rash started to clear, but vomiting became more pronounced, and the patient died on the fifteenth day after a perplexing illness.

The salient post-mortem features were: Consolidation of the left lower lobe surrounding a septic infarct situated at the base of the left lung. Toxic changes in the heart muscle and the kidneys. The stomach showed atrophy of the mucosa and contained a small quantity of food. The duodenum showed adherence of the cap to the undersurface of the liver. Separation of the young adhesions showed a small perforation of the duodenum and a track leading into the liver. The liver was tense and the cut surface showed a large multilocular abscess situated in the right lobe. The abscess cavity was lined by a thin layer of fibrin, and contained foul-smelling pus. In the main part of the cavity was a fishbone, 6 cm. in length, and with a sharp point at the upper end. The bone was the thickness of a stout darning needle.

The other areas of the liver were normal apart from a marked degree of cloudy swelling.

DISCUSSION

Ginzburg and Beller (1927) found that impaction of a foreign body in the small intestine is rare unless herniation of the bowel or a Meckel's diverticulum is present. Impaction, when it occurs, is usually in the lower part of the ileum. Wade (1952) reported 3 cases of perforation of the small bowel. In Case 1 the perforating foreign body was a thorn 3·8 cm. long, and the perforated area a large Meckel's diverticulum. Case 2 showed perforation of the lower ileum by a fishbone 3·8 cm. long. Perforation of a loop of upper jejunum was caused by a 5-cm. chicken bone in Case 3. MacManus (1941) found perforation of the jejunum in only 2 of 95 cases of intestinal perforation due to ingested foreign bodies.

In our *Case* 1 it is interesting to note that the needle was threaded. This points to a man holding the needle between his teeth whilst undertaking some minor sartorial repair, and accidentally swallowing it. Such a sharp object could hardly be expected to pass through the gut without inflicting some damage to the wall of the intestine.

The fishbone found in *Case* 2 was 6 cm. long. This exceeds by 1 cm. the average length of the first part of the duodenum. It is difficult to conceive how a sharp rigid object of this length could negotiate the superior duodenal flexure without perforating the wall of the gut.

SUMMARY

Two cases of liver abscess due to perforation of the alimentary tract are described, and the probable factors influencing the high levels of the perforations indicated.

My thanks are due to Dr. William Whitelaw, Director of Pathology in the Dudley Road Group of Hospitals, Birmingham, for permission to use his autopsy report on *Case* 1, and for his advice and criticism.

I am grateful to Her Majesty's Coroner for Birmingham and Warwick for permission to report these cases.

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REVIEWS AND NOTICES OF BOOKS

Atlas of Tumor Pathology. Sect. II, fasc. 5. *Tumors of the Soft Tissues.* By ARTHUR PURDY STOUT, M.D., New York. $2.00. Sect. IV, fasc. 11. *Tumors of the Major Salivary Glands.* By FRANK W. FOOTE, jun., M.D., New York, and EDGAR L. FRAZELL, M.D., New York. $1.50. Sect. VI, fasc. 21. *Tumors of the Stomach.* By ARTHUR PURDY STOUT, M.D., New York. $1.75. Sect. VI, fasc. 23 and 24. *Tumors of the Retroperitoneum, Mesentery, and Peritoneum.* By LAUREN V. ACKERMAN, M.D., St. Louis, Mo. $1.50. Washington: Armed Forces Institute of Pathology.

THE publication of four new fascicles of the *Atlas of Tumor Pathology*, which was inaugurated some years ago by the Armed Forces Institute of Pathology in Washington, D.C., will be warmly welcomed by histopathologists the world over. In this series Lauren V. Ackerman deals with tumours of the retroperitoneum, mesentery and peritoneum; Frank W. Foote, jun., and Edgar L. Frazell with tumours of the major salivary glands, while Arthur Purdy Stout has compiled the two remaining numbers—tumours of the stomach and tumours of the soft tissues.

The very high standard of previous fascicles of this atlas is well maintained in these recent additions; the illustrations are superb, the text is authoritative, and it is becoming increasingly obvious that the completed Atlas will be an indispensable work of reference for all serious students of tumour pathology.

Medical Art and History in Exeter. An Exhibition of Books, Documents, and Pictures. 8¼ × 5½ in. Pp. 38. 1955. Exeter: Devon and Exeter Medico-Chirurgical Society. 2s. 6d.

THIS small but very interesting pamphlet is in reality a catalogue of books, documents, and pictures which have been on view at the Royal Albert Memorial Musuem, Exeter during April, 1955.

The exhibits for this exhibition came from various sources in Exeter. The books were mostly from the Library of the Cathedral Church of St. Peter and the Exeter Medical Library. The documents and pictures for the most part came from the Archives of the City of Exeter and the Royal Devon and Exeter Hospital.

Mr. Capener is to be congratulated on his excellent pamphlet, which will not only interest medical men in Devon and Cornwall but all those who are interested in medical history both at home and abroad. A valuable catalogue of medical books and pictures in the city of Exeter.

The design on the cover of the catalogue was taken from the Seal of the Hospital of St. Mary Magdalene on a late twelfth century document.

Surgical Technique. By A. V. PARTIPILO, M.D., F.A.C.S., Associate Clinical Professor of Surgery, The Stritch School of Medicine of Loyola University. With a Foreword by ALTON OCHSNER, M.D., F.A.C.S. Fifth edition. 10 × 7 in. Pp. 704, with 548 illustrations. 1953. London: Henry Kimpton. 110s.

THIS fifth edition of Professor Partipilo's text-book contains some valuable new material, but the whole work would have been improved by a more ruthless eradication of what is obsolete. This is a process which is always rather unpleasant, partly because of a sentimental attachment to operations which in their time were regarded as the ideal, and partly because of the respect due to the well-known surgeons who introduced them. Nevertheless, the reputation of a text-book must suffer unless all the outmoded material is cut out, and unfortunately this book has not been adequately pruned.

There is a useful new chapter on Fluid Therapy, the greater part of the surgery of the upper abdomen has been brought up to date, and there is a brief but well-informed section on radiotherapy for breast cancer. On the other hand, the chapters on Hernia and Varicocele, and those on the surgery of the Rectum, Kidney, and Breast are so out of harmony with present-day practice that in spite of the excellence of the illustrations and the general production of the book it cannot be recommended to the post-graduate student of surgery.

Experimental Surgery. By J. MARKOWITZ, M.B.E., M.B. (Tor.), Ph.D., M.S. in Exp. Surg. (Minn.). 9 × 6 in. Pp. 852 + xiii, with 554 illustrations. 1954. London: Baillière, Tindall, & Cox Ltd. 76s. 6d.

THERE is no need to introduce this book to surgeons, for the earlier editions made for themselves a permanent place in surgical literature. This third edition is a good bit bigger and a good bit better even than its predecessor, and in its preparation Professor Markowitz has been assisted by two colleagues at the Ontario Veterinary College, Professor J. Archibald and Dr. H. G. Downie.

It goes without saying that this book should be available to everybody engaged in surgical research, but this is a gross understatement of its widespread appeal to many a surgeon who will never have the opportunity, even if he had the inclination, to undertake experimental work. The book is of the utmost value to every student of medicine as well as to postgraduates making a special study of surgery. Every surgeon, whatever his special interest may be, can profit from it; and anybody who wishes to undertake original work, or to try to teach students the theory or the practice of surgery, would be well advised to consult the appropriate chapters of this book as a proper preparation for his task.

The book is a mine of information, but above all it can inspire a man in the quest for truth and in striving after an ideal—and it has the rare distinction of being written in the clear and forceful style of one who appreciates good English and good literature.

William Clift. By JESSIE DOBSON, B.A., M.Sc., Recorder of the Museum, Royal College of Surgeons of England. 8¾ × 5½ in. Pp. 144 + viii, with 31 plates. 1954. London: William Heinemann Medical Books Ltd. 21s.

"This is all very fine, but it won't do. Anatomy! Botany! Nonsense Sir! I know an old woman in Covent Garden who understands Botany better. As for Anatomy, my butcher can dissect a joint full and well. No, young man; all this is stuff, you must go to the bedside; it is there alone you can learn disease."—THOMAS SYDENHAM to HANS SLOANE.

THIS must have been depressing advice to a young medical man who had the inclination and urge, and was prepared to devote a life-time and a fortune, to accumulate a collection of specimens of plants, fossils, animals, and many other things by the purchase of which, after the Government had bought it from his executors in 1753 for £20,000, and also the King's and Cotton Libraries and the Harleian manuscripts, the foundation of the British Museum was laid. It was due to another collector, John Hunter, that the fallacy of the ideas and words of the English Hippocrates was proven. He had a guiding principle and thought which determined his collection, namely, that it enabled him "to investigate the problems arising out of clinical work with the object of enabling him to treat his patients more rationally and with more chance of success" and this has been verified by many who have followed him.

It was due to William Clift, the subject of Miss Jessie Dobson's book, that surgeons since the time of Hunter have had the priceless possession of the Hunterian Museum as a stimulus and inspiration for their work. John Hunter died on October 16, 1793, but the Government had at that time no inclination to purchase 17,000 specimens of comparative anatomy, physiology, and pathology, together with a large collection of unedited manuscripts and notes. It was not purchased and entrusted to the newly constituted Royal College of Surgeons of London until 1799. In the intervening six years, this boy of 19 years, by his assiduity in the work, loyal devotion to his trust and veneration and love for the wishes of his teacher and master, was able to keep intact this unique collection, though even he could not prevent many of the manuscripts being destroyed by Sir Everard Home after he had not merely plagiarized the contents, but stolen the thought and ideas that had inspired them.

William Clift has had to wait more than a century for his biographer, and all surgeons should be grateful to Miss Jessie Dobson for the loving care, and meticulous accuracy, with which she has drawn the character and personality of "this most admirable man, one who was always ready and willing to help those anxious to learn, and who was never daunted by difficulty and disappointment".

The ideal biography contains everything that serves to throw light upon the subject's character, his mind, his person, and his work, so that at the end the reader can truly say "I now know him". Such a biography must be written with passion, affection, imagination, and understanding, yet without bias or personal prejudice. It is not too much to say that Miss Dobson has achieved this, and the Reader will realize at the end, the amount of research work which lies behind this small book. She is Recorder of the Museum of the Royal College of Surgeons of England, and has had access to all the records, notes, diaries, and letters written by William Clift which are now available in the library of the College; not only has she had the written word, but also the inspiration epitomized in the Hunterian specimens which remain after the destruction of so many during the night of May 10, 1941.

It must be a source of great satisfaction to her that two of the greatest of Clift's successors as Conservators of the Museum, namely Sir Arthur Keith and Professor Frederick Wood-Jones, were spared to read her book, the foreword of which was written by the latter, who up to the time of his death on September 29, 1954, with her help was "engaged in cataloguing and arranging this unique collection" as was the first Conservator who is the subject of her book.

William Clift was born at Barford Hill just outside Bodmin on February 14, 1775; John Hunter was also born on February 14 in 1728. Both were poor country lads who worked in the fields and whose education by many standards was sadly neglected. William Clift was engaged by John Hunter, on the advice of mutual friends, as his amanuensis and apprentice, so these two kindred souls met on Clift's seventeenth birthday. They had been together for only twenty months when Hunter died, but in that short time the personality of the older man had made such an impression, that until the day of his death in 1849 the boy was the substantiated echo of his master. It was a busy life for both, "the day began at six in the morning when they worked together dissecting and preparing new specimens for the museum". Later, while the master was seeing patients and operating, Clift "wrote notes on the new preparations and finished the dissections". In the afternoon he had a drawing lesson and at about six in the evening he joined his master again for the evening's work, answering correspondence, sorting and arranging the descriptions for the new catalogue, and recording cases.

Hunter had appointed Everard Home, his brother-in-law, and Matthew Baillie, his nephew, as his executors. They naturally were anxious to dispose of the Museum as it was Hunter's wish that the Collection should not be dispersed but sold as a whole. Clift, though worried as to his future, just carried on and braved poverty and loneliness in the dreary house in Castle Street where the Museum was housed, on a wage of seven shillings a week. This continued for six years, during which time he looked after the Museum, and earned small commissions by illustrating books, the best known of which is the book on *Morbid Anatomy* by Matthew Baillie, the first text-book on Pathology written in English. He also very fortunately spent long hours copying many of Hunter's manuscripts and notes before Sir Everard Home decided to have them at his own house for the ostensible reason that he wished to make a catalogue of the Collection. These consisted of nine volumes of notes on the dissection of animals; the lectures on surgery, notes for the Croonian Lectures; observations on surgery; cases and notes on comparative anatomy, physiology, and experiments. All these were burned by Sir Everard Home a few days after he had finished his five-volume work entitled *Lectures on Comparative Anatomy*, but Clift had already copied the nine volumes, and twenty-six other monographs, and the lectures had been taken down in shorthand by Hunter's pupils. The Government bought the Collection in 1799 for £15,000 and the Corporation of Surgeons was asked to accept the custody of it, which they did on December 3 in the same year.

As a recognition of his industry and devotion in preserving the Collection, Clift was appointed the first Conservator of the Hunterian Museum under the supervision of a Board of Curators chosen from the Court of Assistants of the newly constituted Royal College of Surgeons of London, and a Board of Trustees. His salary was £80 a year, which was gradually increased, and by 1813 was £300.

Having accepted the custody of the Collection, there was no place to put it in order that it could be exhibited, so it had to be left in the house in Castle Street, off Leicester Square, until suitable premises had been built, with the help of a Government grant, in Lincoln's Inn Fields. They were opened in 1806. Clift superintended the installation of the Collection in the new premises, now known to all as the Royal College of Surgeons of England. He was now married, and had his living quarters over the museum, and was responsible to the Trustees and Board of Curators for the safety of the premises and the contents. From the time that the museum was opened in 1806 his work increased. The collection was exhibited to the public at certain times, and he had to arrange the specimens, conduct parties round, and explain the object of the collection. A library had been inaugurated in 1800 and he was the librarian until 1828, when a separate appointment of Librarian was made. He had to keep the accounts, present them, and attend the meetings of the Trustees, Court of Assistants, and Board of Curators. He had to attend the auctions to purchase additional specimens when other collections were dispersed; direct the two assistants who were appointed to carry out dissections; and be ready at any time to conduct important personages around the Museum. As the collection became better known, and its importance realized, the Museum was visited by Kings, Queens, Emperors, Dukes, Dignitaries of the Church, Scientists from other countries, in addition to the public. It all took time, and as no catalogue was available, he wrote, and made available a short synopsis of the contents, and he also made a catalogue of the pictures, which had a special reference to Hunter's researches, in 1816 and again in 1820. In addition, he had to assemble specimens suitable to illustrate lectures which were given at the College. In 1813 the Executors gave a sum of money to the College to endow an Annual Oration to be delivered in the College on February 14, Hunter's birthday. The first was delivered in 1814 by Sir Everard Home. Since 1853 it has been delivered every second year. In 1820 the Medal and Triennial prize was founded by the Court of Assistants as a further memorial to Hunter.

Clift's reputation as an anatomist and scientific worker was realized by his contemporaries. He was invited to join the newly formed Chemical Society in 1809, he was a member of the Anatomical Society which had been founded in 1796, and the climax of his scientific career was attained on May 6, 1823, when he was made a Fellow of the Royal Society. It was on the following July 26 that Sir Everard Home told him that the manuscripts were burnt and so a catalogue illustrating the Collection, which incorporated the ideas of John Hunter, could never be made. When this became generally known it led to many scathing articles in *The Lancet*, but all acknowledged that Clift was in no way responsible for this catastrophe. The routine of his life and work went on for thirty years, and in 1827 Richard Owen, who was a medical man with a practice and hospital appointment, became his assistant, and later his son-in-law, and finally succeeded him.

If this book is read, in conjunction with the late Professor George Grey Turner's Hunterian Oration given in 1945 on "The Hunterian Museum"; that given on February 14 this year by Sir Cecil Wakeley on "John Hunter and Experimental Surgery"; and some of the previous Orations, it will be realized that what Miss Dobson says of the Museum is correct. "It was, in truth, John Hunter's great unwritten book, and it must always be remembered that had it not been for William Clift, its pages would never have been made available to future generations". He died on June 20, 1849, and on the headstone of his grave in Highgate Cemetery, Richard Owen had the following words inscribed: "He carried a child-like simplicity and single mindedness to the close of a long and honoured career". He was an epitome of the fact that it is not so much the beginning of the work, but the continuing of the same unto the end, until it be thoroughly finished, which yieldeth the true glory.

The publication of the book "was made possible owing to the enlightened generosity of Lord and Lady Webb-Johnson, founders of the MacRae-Webb-Johnson Fund" and for this every surgeon should return them grateful thanks.

Is it too much to hope that we may look forward to a description of more of the historical memorials enshrined in the Hunterian Museum, and precincts of the Royal College of Surgeons of England?

Neurology. By S. A. KINNIER WILSON, M.A., M.D., D.Sc. (Edin.), F.R.C.P. Second edition. Edited by A. NINIAN BRUCE, F.R.C.P. (Edin.), D.Sc. (Edin.), M.D., F.R.S. (Edin.), Lt.-Col. R.A.M.C., Consulting Physician, Bangour Mental Hospital and St. Andrew's Hospital, Hawick; etc. In three volumes. 9½ × 6½ in. Vol. 1, Pp. 702 + index; Vol. 2, Pp. 703–1352 + index; Vol. 3, Pp. 1353–2060 + index. Illustrated. 1955. London: Butterworth & Co. (Publishers) Ltd. £10 10s. Each volume £3 10s.

THE momentous task of bringing this great work up to date has been ably undertaken by Dr. Ninian Bruce, who in 1940 edited the first edition which Dr. Kinnier Wilson at the time of his death was working at and had almost ready for publication. With the appearance of the third volume of this printing, the second edition of the book is now complete. It is both a clearly written and comprehensive account of the modern practice of neurology and a detailed and valuable work of reference. Sir Russell Brain, the President of the Royal College of Physicians, has written a foreword commending the new edition as including the most recent thought in the sphere of neurology while at the same time retaining the touch of Kinnier Wilson's pleasing literary style and simple manner of expression. Sir Russell also writes the chapter on aphasia, apraxia, and agnosia which the first edition lacked, as it had not been written by the original author when his death abruptly terminated his work on the book. A chapter on neurosyphilis has been revised by Dr. Nevin, who also writes on its treatment.

The important contributions which Kinnier Wilson made to neurology generally and the added prestige which he thereby gave to British Neurology, make this a memorable contribution, and the present editor is to be congratulated on the success which he has achieved in modernizing the book without destroying its original framework. It should be a popular work of reference with consultants, practitioners, and all who are interested in the diseases of the nervous system.

X-ray Atlas and Manual of Esophagus, Stomach and Duodenum. By Dr. T. J. J. H. MEUWISSEN, Eindhoven, Holland. With an Introduction by ROBERT D. MORETON, M.D., F.A.C.R., Fort Worth, Texas, U.S.A. 11 × 7½ in. Pp. 687 + xiv, with 1201 illustrations. 1955. Amsterdam: Elsevier (London: Cleaver-Hume Press Ltd.). £8 15s.

FROM the radiological point of view this large volume covers the subject of diseases of the œsophagus, stomach, and duodenum in an excellent way.

The author has been collecting data and radiographs for his book for over a quarter of a century and his mature and practical experience comes to the fore in its pages. There are some 1201 radiographs in this atlas and they are all of a high order, and are mainly of adult organs. The foregut is probably the most important part of the alimentary tract from the clinical point of view, and especially so from the radiological aspect.

Dr. Robert D. Moreton, of Texas, writes an introduction to this book and praises it as a valuable tool in the field of gastro-enterology. The book is divided into four main parts: The first deals with the œsophagus, the second with the stomach, the third with the duodenum, while the fourth part is devoted to a consideration of the post-operative stomach. In each part there are numerous case reports and photographs of surgical specimens removed at operation and confirming the X-ray examinations.

This book will be used as a reference volume for many years to come, as it is the best X-ray atlas which has so far been produced.

Practical Management of Disorders of the Liver, Pancreas, and Biliary Tract. By JOHN RUSSELL TWISS, M.D., F.A.C.P., and ELLIOTT OPPENHEIM, M.D., F.A.C.P., Assistant Professors of Clinical Medicine, New York University Post-Graduate Medical School; etc. 9¼ × 6 in. Pp. 653, with 136 illustrations and 7 plates, 3 in colour. 1955. London: Henry Kimpton. £5 10s.

DISEASES of the liver and pancreas form a large part of the work of the modern physician and surgeon. Quite a number of these diseases are problems in themselves and, therefore, a monograph devoted to the diagnosis and management of these disorders is opportune.

It is now understood that disorders of the liver have their effect on the pancreas, gall-bladder, and bile-ducts, and vice versa.

We are glad to see that the authors of this work stress the great importance of clinical examination and observation, and place the various laboratory tests in their proper perspective. Duodenal drainage is stressed as it provides information regarding the patency of the extrahepatic duct system and the motor activity and concentrating mechanism of the gall-bladder. It also provides information regarding the presence or absence of bacterial infection in the bile. Too often to-day the nonsurgical drainage of the biliary tract is completely neglected.

There is an excellent chapter devoted to the pathogenesis, classification, and differential diagnosis of jaundice which is well worth study.

The illustrations are numerous and good, especially the coloured plates.

This book will take its place as one of the really useful books dealing with the liver and pancreas.

Correlative Neurosurgery. By EDGAR A. KAHN, ROBERT C. BASSETT, RICHARD C. SCHNEIDER, and ELIZABETH CAROLINE CROSBY. With eleven other contributors. Foreword by KENNETH G. MCKENZIE, Toronto. 11 × 8¾ in. Pp. 413 + xvi, with 235 illustrations. 1955. Springfield, Ill.: C. C. Thomas. (Oxford: Blackwell Scientific Publications.) £7.

THIS monograph comes from the teaching centre at Ann Arbor and reflects the teaching of that great surgeon, Max Peet, who was as well known in England as in America. The contributors for the most part hail from the University of Michigan Medical School.

Although this book has been written primarily for the younger neurosurgeon, it should also prove of value to the practitioner and medical student as a source of fundamental knowledge. It embodies the clinical and operative experience of the Neurosurgical Clinic of the University of Michigan Medical School. There has been an excellent attempt in many of the chapters to correlate neuro-anatomy with neurosurgery. The illustrations are well drawn, with not too much detail, and are most helpful to the reader. In the chapters on cerebral tumours, full-size gross sections have been used because the authors believe that this makes the surgical anatomy clearer; and there is no doubt that this is so.

There are chapters on electroencephalography, endocrinology, radiography of the skull and spinal cord, and aphasia.

This monograph should prove most useful to any young surgeon who contemplates making neurosurgery his speciality.

Operative Orthopedic Clinics. By LEWIS COZEN, M.D., F.A.C.S., Assistant Professor of Orthopedic Surgery, College of Medical Evangelists, Los Angeles; etc.; and ALVIA BROCKWAY, M.D., Chief of Staff Orthopedic Hospital, Los Angeles. In collaboration with PAUL E. MCMASTER, M.D., F.A.C.S., Clinical Professor of Orthopedic Surgery, University of California, Los Angeles. 10 × 7 in. Pp. 329 + xii, with 310 illustrations. 1955. Philadelphia: J. B. Lippincott Co. (London: Pitman Medical Publishing Co.) 80s.

THIS rather large volume describes in detail the operative treatment of all the commoner orthopædic conditions as well as those fractures which require surgical intervention. The illustrations are for the most part line drawings, but they do enhance the reading of the text.

The remarks at the end of each operation represent the opinions of the authors and there is not necessarily a unanimity of agreement.

One is glad to see that Syme's amputation is still performed in America, and that opinion there is that it is a good amputation for irreparable traumatic conditions of the foot.

This book enables the reader to realize the extent of orthopædic surgery in Los Angeles, and it appears that skeletal traction is more commonly used there in the treatment of fractures than it is in England.

Abdominal Operations. By RODNEY MAINGOT, F.R.C.S. (Eng.), Surgeon to the Royal Free Hospital, London, and to the Southend General Hospital. Third edition. 9¾ × 6¾ in. Pp. 1580 + xiv, with 738 illustrations, including 11 coloured plates. 1955. New York: Appleton-Century-Crofts Inc. (London: H. K. Lewis & Co.) £8 10s.

THE new third edition of this well-known work will be very welcome to surgeons both at home and abroad. It is some seven years since the second edition was published and much has happened to surgery and surgical technique in the intervening years. The whole volume has been revised and many new contributors have been employed and this has necessitated some 300 more pages.

One of the pleasing features of this work is the wealth of good illustrations, there being 738 in all, including 11 coloured plates; this provides more than one illustration per page.

This new third edition is the best of the three; it is comprehensive, well written, and superbly illustrated, and the editor and his contributors are to be congratulated on their achievement.

This work is a great credit to British and American Surgery. It is far and away the best book on abdominal operations.

Surgery of the Heart. By CHARLES P. BAILEY, M.D., M.Sc., (Med.) Ll.D. (Hon.), F.A.C.S., F.C.C.P., F.I.C.S., Professor and Head of Department of Thoracic Surgery, Hahnemann Medical College and Hospital, Philadelphia, Pa.; etc. 9¼ × 6 in. Pp. 1062. with 671 illustrations and 3 coloured plates. 1955. London: Henry Kimpton. £9.

THERE are few branches of surgery that have progressed more in the last decade than that devoted to the heart. It is fitting therefore that one of the pioneers of cardiac

surgery should write a comprehensive work devoted to this subject.

Professor Bailey with his matured clinical background, has written an interesting and well-balanced book which is well illustrated with a wealth of good drawings, radiographs, and photographs of clinical cases and pathological specimens.

The whole medical profession has welcomed the surgical treatment of mitral stenosis, especially when it is considered how common rheumatic valvular damage is these days.

This book covers in an excellent manner the extensive field of cardiac lesions which are treated by surgical intervention to-day. Professor Bailey has divided his work into three main parts: the first deals with general considerations and includes anæsthesia in cardiac surgical operations, cardiac resuscitation, hypothermia, the heart-lung machine, and exploratory surgery of the heart. The second part of the book is devoted to the surgery of congenital heart disease; while the third part deals with the surgery for acquired heart disease.

We would like to congratulate Professor Bailey on his life's work—it is a wonderful production and will long remain the reference volume on cardiac surgery.

The Skin. A Clinicopathologic Treatise. By ARTHUR C. ALLEN, M.D., Associate Pathologist, Memorial Hospital, New York; etc. 11½ × 8½ in. Pp. 1048 + xvi, with 495 illustrations as full-page plates. 1954. St. Louis: C. N. Mosby Co. (London: Henry Kimpton.) £9 7s. 6d.

THERE can be no doubt that dermatology is one of the most difficult branches of medicine, and both students and practitioners find it a perplexing subject. Any book which gives the main clinical symptoms combined with a good clinical photograph and a photomicrograph of all and every skin condition is bound to be both useful and popular. Dr. Arthur C. Allen has written and illustrated such a book. Approximately a quarter of the book has been devoted to neoplastic diseases, and it is this part which interests the surgeon for the most part.

There are some 495 full-page illustrations in this large volume and they are all well chosen and beautifully reproduced. It is hard to conceive a better arrangement than that which the author has followed in this book; its presentation and format are excellent.

Although primarily intended for dermatologists and physicians, this book should prove of value to the pathologist and surgeon alike, for they both have much to learn from it. An admirable production.

BOOK NOTICES

[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest to our readers.]

Chirurgie de la Main. By MARC ISELIN, Surgeon to the Maison de Nanterre. Consulting Surgeon to the Hôpital Américain. Second edition. 9½ × 6½ in. Pp. 626, with 319 illustrations. 1955. Paris: Masson. 4,000 fr.; cloth, 4,800 fr.

The Sherrington Lectures. III. The Invasive Adenomas of the Anterior Pituitary. By Sir GEOFFREY JEFFERSON, M.S. (Lond.), F.R.C.S., F.R.S., Emeritus Professor of Neurosurgery, University of Manchester. 8½ × 5½ in. Pp. 64, with 25 illustrations. 1955. Liverpool: University Press. 5s.

An Outline of the Treatment of Fractures. By the Committee on Trauma, the American College of Surgeons. 8¼ × 5¼ in. Pp. 98, with 45 illustrations. 1954. Chicago: The American College of Surgeons.

Early Care of Acute Soft Tissue Injuries. By the Committee on Trauma, the American College of Surgeons. 8¼ × 5¼ in. Pp. 194. Chicago: The American College of Surgeons.

Essentials of Orthopædics. By PHILIP WILES, M.D., F.R.C.S., F.A.C.S., Senior Orthopædic Surgeon, The Middlesex Hospital, London; etc. Second edition. 9⅝ × 6¼ in. Pp. 538 + xvi, with 393 illustrations. 1955. London: J. & A. Churchill. 65s. net.

Christopher's Minor Surgery. Seventh edition. Edited by ALTON OCHSNER, M.D., F.A.C.S., William Henderson Professor of Surgery, Tulane University of Louisiana School of Medicine; and MICHAEL E. DEBAKEY, M.D., F.A.C.S., Professor of Surgery, Baylor University College of Medicine. 9 × 6¾ in. Pp. 547 + xvi, with 251 illustrations. 1955. Philadelphia and London: W. B. Saunders Co. 63s.

Man in a Cold Environment. Physiological and Pathological Effects of Exposures to Low Temperatures. By ALAN C. BURTON, Ph.D., Professor of Biophysics, University of Western Ontario; and OTTO G. EDHOLM, M.B., B.S., Head of Division of Human Physiology, National Institute for Medical Research. Medical Research Council, England. Being Monographs of the Physiological Society, No. 2. 8½ × 5½ in. Pp. 273 + xiv, with 75 illustrations. 1955. London: Edward Arnold (Publishers) Ltd. 30s.

Antibiotics Annual, 1954-1955. Proceedings of the Second Annual Symposium on Antibiotics. Edited by HENRY WELCH, Ph. D., and FELIX MARTI-IBAÑEZ, M.D. 10 × 6¼ in. Pp. 1154 + x. Illustrated. 1955. New York: Medical Encyclopedia, Inc.

Chirurgie Reparatrice. By MERLE D'AUBIGNÉ. 10½ × 7¼ in. Pp. 268, with 176 illustrations. 1955. Paris: Expansion Scientifique Française. 3,900 fr.

Fractures and Joint Injuries. By SIR REGINALD WATSON-JONES, F.R.C.S., F.R.A.C.S. (Hon.), F.A.C.S. (Hon.), Extra-Orthopædic Surgeon to Her Majesty The Queen. Volume II, second edition. 9 15/16 × 6½ in. Pp. 630 + x, with 904 illustrations, many in colour. 1955. London: E. & S. Livingstone Ltd. 120s. per set.

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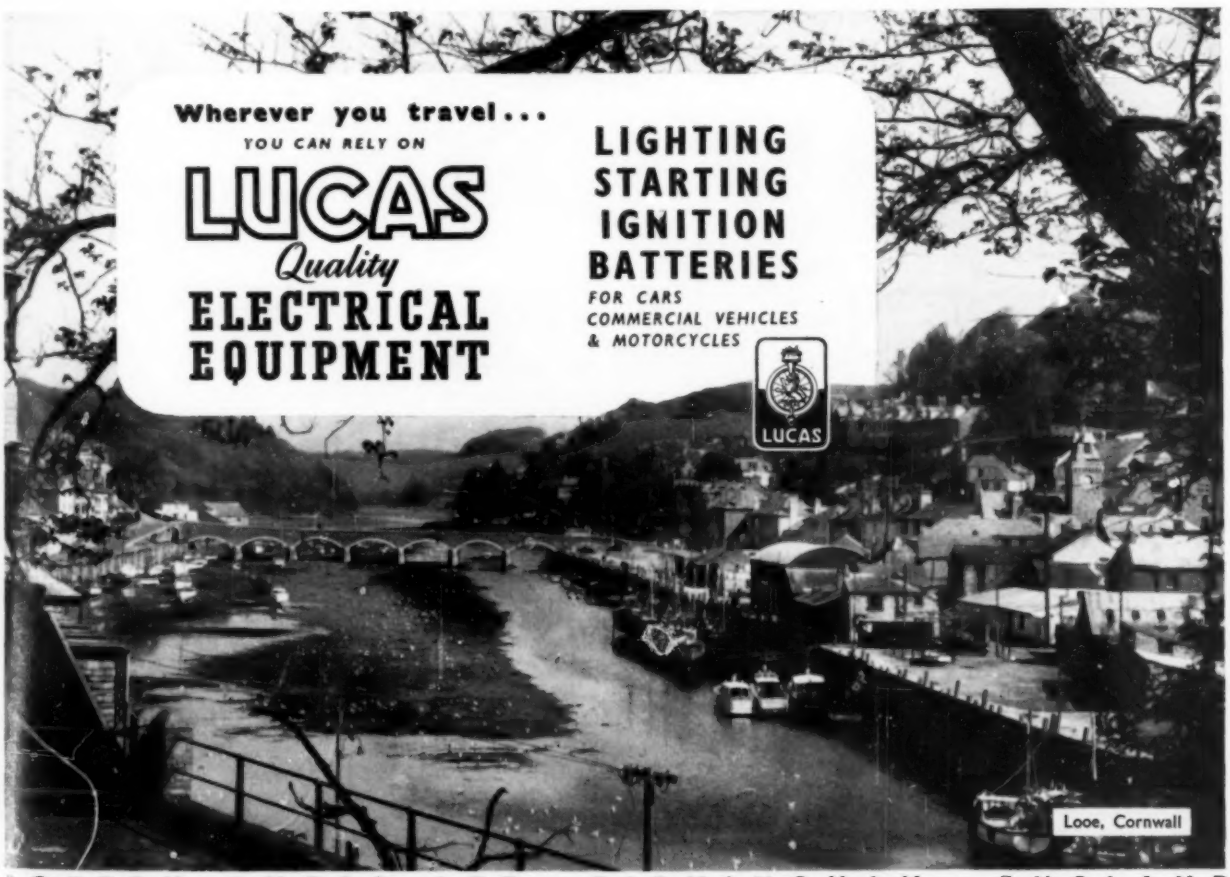

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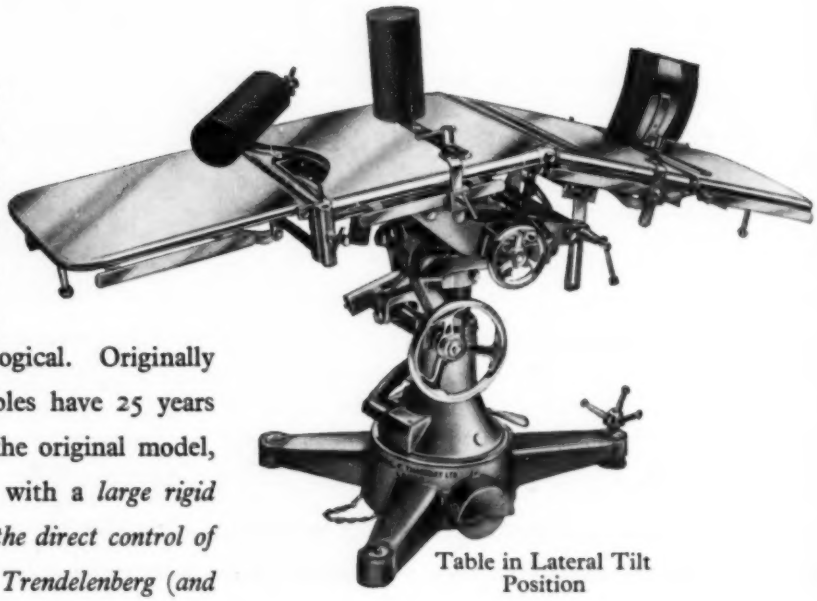

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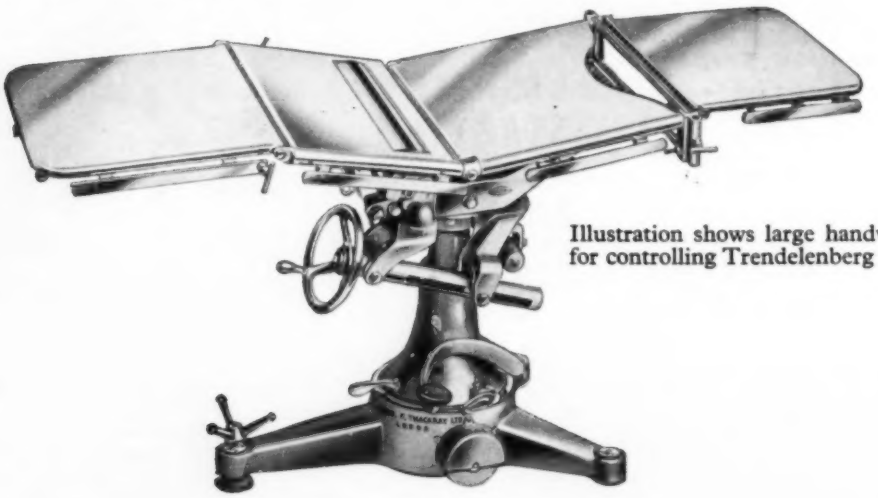

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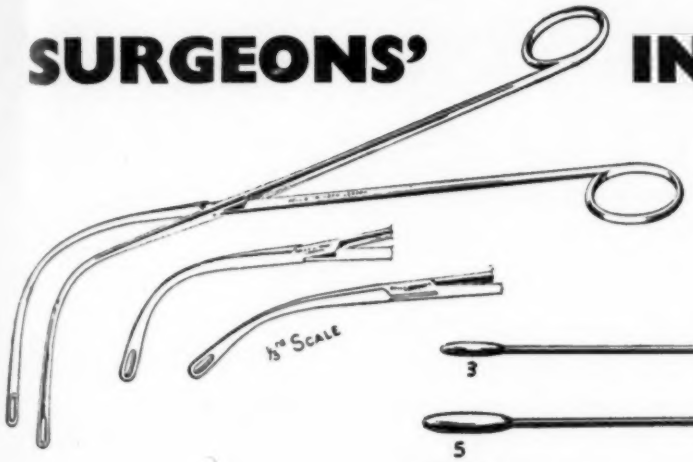

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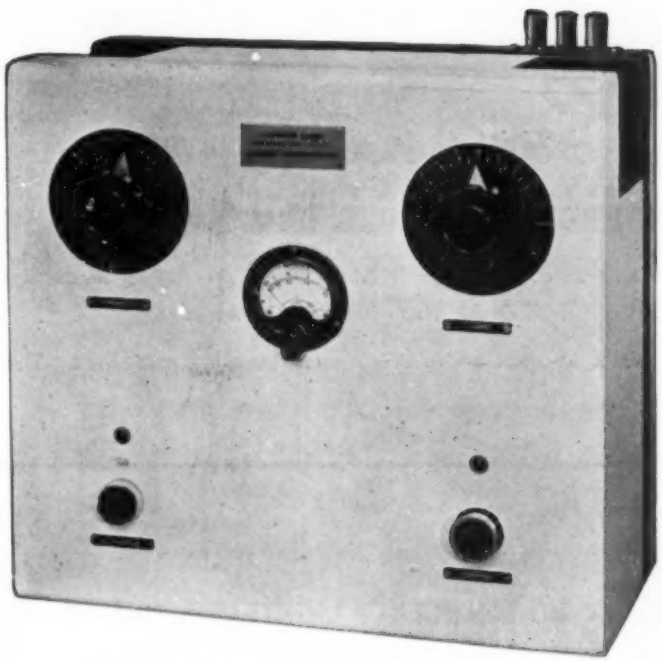

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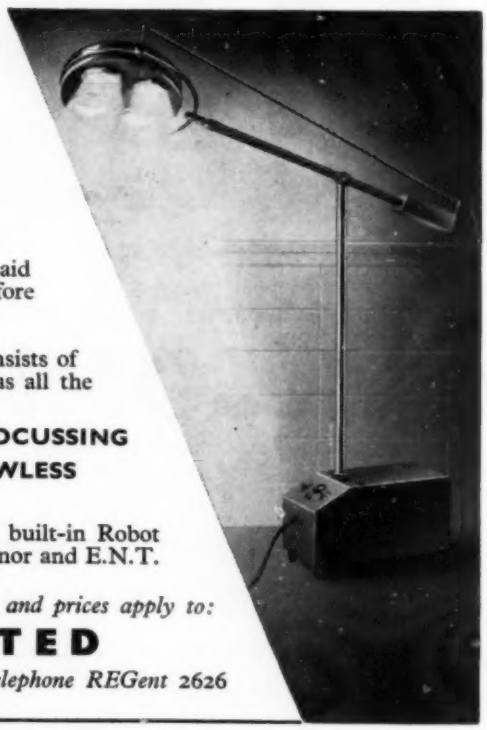

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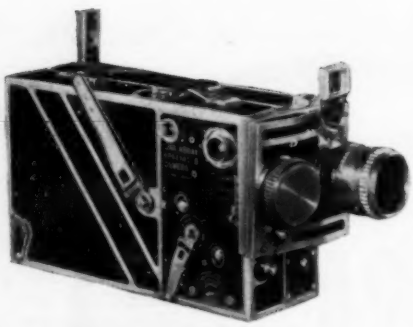

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